COGNITIVE STRUCTURES, STRATEGIES AND INSTRUCTION

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SUMMARY

This thesis is organised into three parts. In Part 1 relevant literature is reviewed and three critical components in the development of a cognitive approach to instruction are identified. These three components are considered to be the structure of the subject-matter, the learner's cognitive structures, and the learner's cognitive strategies which act as control and transfer devices between the instructional materials and the learner's cognitive structures.

Six experiments are described in Part 2 which is divided into two methodologically distinct units. The three experiments of Unit 1 examined how learning from materials constructed from concept name by concept attribute matrices is influenced by learner or experimenter controlled sequence and organisation. The results suggested that the relationships between input organisation, output organisation and recall are complex and highlighted the importance of investigating organisational strategies at both acquisition and recall. The role of subjects previously acquired knowledge and skills in relation to the instructional material was considered to be an important factor.

The three experiments of Unit 2 utilised a "diagramming relationships methodology" which was devised as one means of investigating the processes by which new information is assimilated into an individual's cognitive structure. The methodology was found to be useful in identifying cognitive strategies related to successful task performance. The results suggested that errors could be minimised and comprehension improved on the diagramming relationships task by instructing subjects in ways which induced successful processing operations.

Part 3 of this thesis highlights salient issues raised by the experimental work within the framework outlined in Part 1 and discusses potential implications for future theoretical developments and research.

KEY-WORDS

Cognitive Structures
Cognitive Strategies
Instruction

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"Opportunities of investment are useful only to those who have capital. Any piece of knowledge I acquire today, a fact that falls under my eyes, a book I read, a piece of news I hear, has a value at this moment exactly proportional to my skill to deal with it. Tomorrow, when I know more, I recall that piece of knowledge and use it better."

R. W. Emerson (1857)

PART 1

PART 1 - INTRODUCTION

PART I - INTRODUCTION

Part I of this thesis is a general introduction to those areas of cognitive psychology considered to be important to the problems of task analysis and instructional design. The first section (1.1) broadly overviews the cognitive position and identifies three critical components in the development of a cognitive approach to instruction. These three components are considered to be the structure of the subject-matter (discussed in section 1.2), the learner's cognitive structures (discussed in section 1.3) and learning strategies (discussed in section 1.4). Learning strategies are considered to act as control and transfer devices between the instructional subject-matter and the learner's cognitive structures.

1.1 COGNITION AND INSTRUCTION

Psychology is only one of the many disciplines which is shaping the emergence of the new cognitive science. This introductory section is an overview of current research and ideas in cognitive psychology and their application to the problems of instructional design.

Cognitive theories of psychology assume that knowledge can be separated from the purpose for which it was acquired and internally represented in a more general symbolic form. Two distinctive theoretical orientations can be distinguished within contemporary cognitive psychology. The first, the information-processing theory, has an underlying theoretical perspective that the primary function of the human brain is to actively select, acquire, organise, store and at appropriate times retrieve and utilise information. Since this approach forms the basis for most modern learning theories, it is introduced in more detail in the subsequent section (1.1.1). The second theoretical orientation, the psycholinguistic approach, has become an increasingly important area of psychology over the last two decades principally because the construction of a language grammar is in effect a hypothesis concerning structural descriptions of knowledge.

The concept that organised knowledge structures exist in memory and that information input is processed in terms of such structures has become a central idea in cognitive psychology. Consequently, cognitive structures and their importance in learning and instruction are discussed in section 1.3.

Two basic emphases are apparent within the framework of information processing theory. The first concentrates upon the structure of the human information processing system, the second on the processes which must underly its successful function. Recent work suggests that the sequence of information processing is not structurally pre-determined as is suggested by the traditional information-processing flowchart. Rather, as Underwood (1978) points out, whilst the response may be structurally limited, the strategies of encoding and retrieval play a vital role. Whatever information-processing strategies are selected by a learner, they will be a manipulation of presented information using available cognitive structures, which will themselves transform and encode the information in a variety of ways. The concept of cognitive strategy is introduced in this introductory chapter and considered in greater detail in section 1.4.

The term "instruction" is used in the present discussion to refer to any set of environmental conditions that are deliberately arranged to foster increases in competence or performance. Competence refers to what is learned whereas performance refers to the behaviour which manifests that learning. Chomsky (1965) formulated the distinction between competence and performance and the issues relating to these terms has subsequently been extensively debated (Bever, 1970; Fillenbaum, 1971; Hayes, 1970). As Glaser (1976) observes, the process of instruction is concerned with the development of competence in a learner and with the behaviours and cognitive structures that differentiate the novice from the competent performer. The term "instructional design" is taken to refer to attempts to describe entry behaviour, to organise suitable sub-task sequences and to provide opportunities for learning.

In the context of behavioural science, instruction is generally characterised by several central elements. These typically include behaviouristic analyses of instructional tasks, specifiable behavioural objectives, highly prescribed instructional materials and well-defined procedures for observing and measuring the outcomes of learning. The development of a cognitive theory of instruction requires a means of describing states of cognitive competence and of ultimately relating those states to manipulations of the instructional environment. A desirable objective of any instructional programme might be to encourage learners to formulate strategies to aid problem-solving and adaptive behaviour. External guidance is not always possible and may not be always desirable (Singer, 1978). It is clear, however, that in attempting to bring the constructs of psychology to bear on the problems of instructional design, task analysis plays a central role. Irrespective of the model of the learner adopted, the defining and ordering of what the learner must master (ie task analysis) is a key concern. The role of task analysis is consequently considered in greater detail in Section 1.2 where its application in determining the structure of instructional materials (subject-matters) is discussed.

1.1.1 Cognitive learning theory

Carroll (1976) has reviewed "naive", behaviouristic and cognitive theories of learning. He assumes that a "naive" or common-sense theory of learning has existed for centuries and that the "instructional procedures" used by most people utilise aspects of this theory. "Naive" refers to the common-sense psychology that people have about their behaviour and motives (Heider, 1958) and is not intended to be a deprecatory term. Carroll (1976) contends that certain features of the naive theory have been selected for analysis and reinterpretation by behaviour theory. The salient features of behaviour theory is its treatment of the relations among stimuli, overt responses and reinforcements. Advocates of this approach have traditionally ignored the individual learner since in its strict form mental events and covert responses are not considered. In contrast a cognitive learning theory is one that would embrace covert events such as expectancies, plans, sets, images, memory storage and retrieval, conscious control and complex information processing. Any completely adequate cognitive theory of learning has not yet been developed but, in general, cognitive theorists assert that thought is the product of inner organisation and restructuring. The attention of the cognitive theorists focuses on the present inner mental state of the individual. These states include cognitive structures (e.g. Ausubel, 1968) plans and images (Miller, Galanter and Pribram, 1960) strategies of thinking (e.g. Bruner, et al 1956) and cognitive styles (e.g. Kagan et al 1964).

Within the human-information-processing analogy cognitive structures are the systems which analyse the information passed to them by earlier systems and perform such functions as perception, encoding, language comprehension, problem-solving and the control of overt action. Information processing studies, in contrast to earlier analyses of performance, attempt to account for task performance in terms of actions (internal or external) that take place in a temporally ordered flow.

The processes which have been postulated are those that make certain kinds of transformation (identified as stages of processing) of inputs to outputs. The processing of any information extracted from the environment can therefore be analysed into a series of stages of processing. From the cognitive perspective, task analysis is the study of complex performances so as to reveal the psychological processes involved. Since task analysis of some kind is involved whenever performances are analysed into components they are therefore pervasive in psychological research. These analyses can provide psychologically rich descriptions of competence (Resnick, 1976). The role of task analysis in translating subject-matter descriptions into psychological descriptions of behaviour is considered in Section 1.2.

The essential features of most information processing theories of learning and memory are represented in Fig. 1.1.

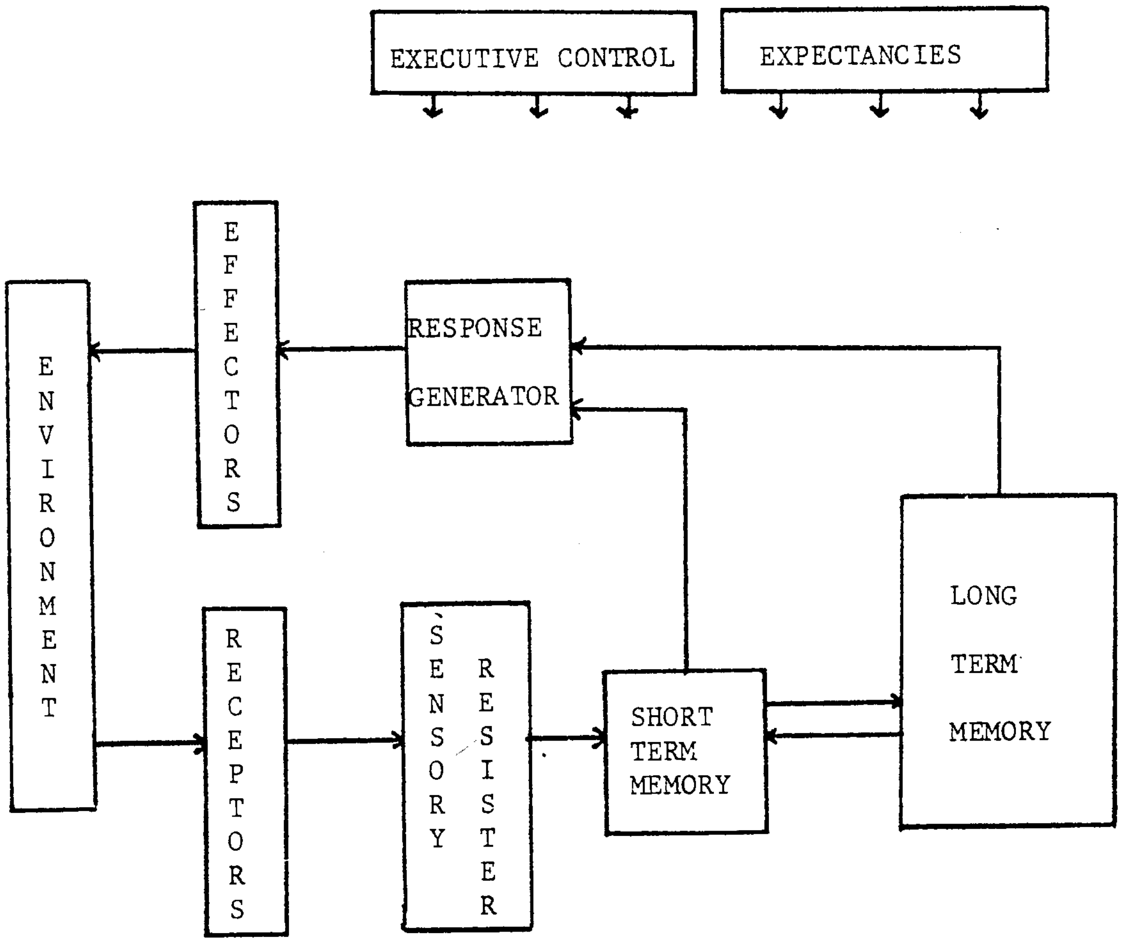

Fig. 1.1 The basic information-processing model of learning and memory (After Gagné, 1975).

Stimulation from the environment impinges upon the learner's receptors and initially information is coded in the sensory register. The sensory register is responsible for the initial perception of objects and events and information remains in this structure very briefly until the information passes into the short-term memory.

Information is coded into a conceptual form in short-term memory and persists for only a matter of seconds in this form. Internal rehearsal may preserve the information in short-term memory for longer periods and this form of processing may also play a role in the transformation of information to-be-remembered into long-term-memory.

Short-term and long-term memories may not be different structures, but only different ways of functioning of the same structure. When new learning depends partly on the recall of something that has been previously learned, it is clear that appropriate information must be retrieved from long-term-memory and must re-enter short-term-memory. Recent work (e.g. Kintsch and Van Dijk, 1978; Mandler, 1979; Spilich et al, 1979) suggest that in order to understand processes of learning and comprehension, it is necessary to know how existing knowledge is represented and how that representation is utilised in the acquisition of new information. From this theoretical stance, it is apparent that virtually all learning can be regarded as transfer. Section1.3 examines in more detail some aspects of the cognitive representations of knowledge.

Information which has been retrieved from either short-term or long-term memory passes to a response generator which transforms the information into a neural "message" which activates the effectors.

Consequently performance can be observed.

1.1.1.1 Information processing strategies

From the classical work of Broadbent (1958) onwards, the primary aim for models of attention, skill and information processing has been to discover what stages of processing need to be postulated and what their order and interrelationship must be to account for the phenomena of behaviour. There has been a greater research emphasis on the details of structure than with the dynamics of processing. As Newell (1973a & b) observes, this emphasis on cognitive structure rather than cognitive strategy has given rise to a too narrow concern for the structure of cognitive process. In any situation an individual brings both his structural limitations and his repertoire of strategies. The structural view of behaviour can only provide a restricted appreciation of the adaptive learner. As Moray (1978) points out, the key issue is to separate out structure from strategy in the necessary rapprochement between the two approaches.

The structures labelled executive control and expectancies in Fig. 1.1 are concerned with the control of the information flow in a way which determines the transformations which the information undergoes. This control is made possible by cognitive strategies, which are internally organised capabilities which the learner makes use of in guiding his own attending, learning, remembering and thinking (Gagné, 1975). A cognitive strategy consists of a sequence of cognitive acts involving shifts in attention and transformation of objects. Thus in any problem-solving task or learning situation, a complete description of the psychological problem space must include both representations (cognitive structures) and the set of operators (cognitive processes) to be applied. Cognitive strategies involve the representational capabilities of the learner (e.g. reading, imagery, speech) selectional capabilities (attention and intention) and self-directional capabilities (self-programming and self-monitoring) and are crucial to an understanding and analysis of cognitive performance.

1.1.2 A cognitive view of instruction

Any complete cognitive learning theory is not yet apparent but it is clear that the cognitive approach has replaced behaviourism as the dominant school of thought in experimental psychology. Application lags behind basic research and unfortunately the present status of a cognitive theory of instruction is reflected in the simple non-mathematical description required for its expression. Simon (1969) has distinguished a prescriptive science of design from an explanatory descriptive science. In general, a prescriptive science provides a framework for the professional in the field, and for developers of applications who provide the professional with tools, techniques and instrumentation. In the application of a cognitive learning theory to the problems of instructional design, serious development of a prescriptive linking science between explanatory science and professional application is required. In attempting to construct a cognitive theory of instruction, the nature of knowledge and performance, the nature of the communicable and instructable, and the nature of experience are conceptual issues that must be faced (Olson and Bruner, 1974).

In the traditional approach to education and training, the primary goal has been to teach content-specific subject-matters. Learning-to-learn had been recognised in the literature of verbal learning only as a bi-product of practice in rote memorisation (e.g. Postman, 1969). An increasing number of investigations have recently been exploring the possibility of using cognitive strategies to facilitate the acquisition, retention and retrieval stages of learning. According to this view of instruction, the instructional sequence is designed to help the learner to develop and to organise internal mediational processes (Rigney, 1978). Cognitive strategies vary in generality and applicability. General strategies are those that transfer to a wide variety of situations. Mental imagery, for example, seems to be applicable in a variety of learning tasks (Bower, 1972). Converting the letters of CVC's to words that form meaningful phrases clearly is a strategy of less generality.

In emphasising the importance of the concept of strategy is the acknowledgement that behaviour is extremely variable. Two individuals will behave differently in the same environmental situation and the same individual may behave differently in the same situation at different times. Although there are structural limitations to the processing of information, often the individual learner's strategic manipulations appear to negate the concept of limited capacity. Apparent multiple task performance or the simultaneous operation of two stages of processing have often been reported (e.g. Allport et al, 1972; Underwood, 1974). Rather than denying that the processor and its components have a limited processing capacity available at any one time, these studies demonstrate the strategical operation of expectancy and the appreciation of redundancy both in the environment and in the response system capacity.

Capacity limits cannot, by definition, be overcome by instructional manipulations although proficiency limits can be overcome by practice at tasks in which appropriate strategies are used. An individuals ability to learn in an effective and meaningful way is limited both by structural limitations and by the extent to which old skills and knowledge can be brought to bear to the learning situation. The stages of learning (i.e. acquisition, retention and retrieval) are composed of processes operating both on the presented subject-matter and on the learner's existing structure of knowledge. Although strategies are always performed by the learner, initiation of their use may come from the learner's self-instruction or from an external instructional system.

Instructional task analysis and design can therefore be usefully described as the identification of a complete set of cognitive strategies sufficient to the task, the mapping of suitable strategies onto a learners current knowledge and skills, and finally the development of instructional methods and materials which encourage the acquisition of the most useful strategies.

The structure of the subject-matter, the learners' cognitive structures, and the learner strategies which act as control and transfer devices constitute the three critical components in a cognitive approach to the problems of task analysis and instructional design. These three areas are discussed in more detail in sections 1.2, 1.3,and 1.4 respectively.

1.2 SUBJECT-MATTER STRUCTURE

People's abilities to learn and remember are strongly influenced by the nature of the instructional subject-matter. Task analysis attempts to analyse performance into components in order to define and structure what a learner must master. A pre-requisite before task analysis is attempted in any context is the establishment that tasks are consistent with what the system (or theories) which gave rise to them is trying to achieve. As Duncan (1975) observes, this much appears to be common to both education and occupational training, although different task analysis approaches have generally been advocated for each area. Although training and education can be seen as two aspects of the teaching process, a distinction is often drawn between the more general and varied objectives of education and the more specific and prescribed objectives of training. Duncan (1975) has pointed out that existing objectives in education are generally regarded as given whereas in occupational training, instructional objectives are typically subject to rigorous examination in terms of their eventual contribution to systems objectives.

Selecting and stating instructional objectives on the basis of what a person does rather than an underlying theory has been the "behavioural operationalism" approach adopted by Miller (e.g. Miller, 1953; 1966) and Mager (1962). This type of approach and analysis techniques which have stemmed from it (e.g. Annett and Duncan, 1967) have been fairly successful, particularly in the context of occupational training. When instructional theory is concerned with the adoption of behavioural objectives and the development of specific instructional programmes relating to systems objectives, then cognitive approaches might be regarded as an extravagance. However, in the possibility that individuals can be taught to be more effective learners independent of a particular instructional subject-matter lies much of the untapped potential of the cognitive approach. The learner's cognitive involvement in the form of learning how to formulate rules and strategies to cope with newly-introduced tasks could enhance the probability of successfully confronting similar tasks in the future.

Clearly the type and organisation of the subject-matter is an important consideration for both the application of learners' cognitive strategies and the design of instruction. This chapter examines some of the current ideas and ramifications of this central instructional area.

1.2.1 Structure: some interpretations

In the analysis of instructional materials, the concept of "structure" is frequently invoked. The variety of uses of the term has expanded rapidly over the years to the extent that there is no generally accepted referent to the term. At first examination, it is difficult not to agree with Kroeber's (quoted in Nadel, 1957) caustic comment,

> "Structure appears to be just a yielding word that has a perfectly good meaning but suddenly becomes fashionably attractive ..... and during its vogue tends to be applied indiscriminately because of the pleasurable connotations of its sound."

The terms "organisation" and "structure" are used in almost every contemporary discussion but the meanings of the terms are not easily specified. There appears to be no consistent conceptual difference between the use of the two terms. One general kind of distinction is that structure refers to the overall pattern or configuration of the representations of a set of elements (hierarchical, linear, etc.) whereas organisation refers to the specific relations among the elements in the configuration (e.g.reflexivity, symmetry, transitivity, etc.). (The specific use of the term "organisation" in the context of the clustering of categorically related items in free-recall is discussed within unit 1 of the experimental work.)

Shavelson and Geeslin (1975) have defined structure as an assemblage of identifiable elements and the relationships between those elements. Expressed in set-theoretic terms, structure means:

(i) A finite non-empty set of elements S, and

(ii) a finite non-empty set of relations R.

The set S can be any set of objects under study, and the set R can be any set of relations. This mathematical definition of structure provides some precision, and is briefly introduced here as set theoretic descriptions, are used at various points in this thesis. This mathematical model is basically simple but has the advantage that complexity can be added to it in a systematic manner.

Structure may be objective and "real" or subjective and internal (Shavelson, 1972). Frase (1973) calls the a priori structure, which presumably has some objective reality, "external structure". As Frase points out it may be impossible to prove the "correctness" of any particular structural analysis. However, it is generally agreed that some subject-matters do have a structure and that instructional decisions can be made if that structure is known.

Properties of individual elements (words for example) can influence performance on learning and memory tasks. Although such variables as meaningfulness (Underwood and Schultz, 1960), imagery (Paivio, 1971) and frequency (Underwood and Schultz, 1960) have been demonstrated to be important, these variables are highly correlated (Christian et al, 1978). Further, because these variables have been shown to have only a partial relation to retention, other variables must be operating. Words are generally encountered structured in a form to produce sentences and paragraphs. Linguistic structures have been shown to have powerful effects on learning and retention. Miller and Selfridge (1950), for example, manipulated the degree to which lists of words approximated the kinds of structures found in normal English and demonstrated that recall improved as the list's approximation to English increased. Bower and Clark (1969) found recall of word lists was greatly improved when subjects formed linguistically appropriate links between the words.

Although, it has been argued that learner perception of appropriate linguistic structures are based on the frequency with which certain words have followed one another in previously encountered sentences, this view is no longer favoured. Because individuals can understand an unlimited number of novel sentences, Chomsky (1957, 1975) has pointed out that knowledge of language cannot be equivalent to word-by-word or even phrase-by-phrase probabilities based on prior frequencies of experience.

There are many levels of linguistic structure and an exhaustive examination of the wide range of issues involved is outside the scope of this discussion. Suffice it to say that the analysis of deep or conceptual structure is not simply a problem for linguistics since psychological models of understanding and memory must deal with this issue as well. Some aspects of these organised structures are considered in Section 1.3.

In the analysis of the structure of semantically-related sentences including coherent text or discourse subject-matters, analysis must go beyond an analysis of individual sentences. The constructivist notion that people frequently combine semantically-related sentential information to form more holistic or integrated structures is considered in more detail in Section 1.3 and in the experiments of Unit 2.

Many aspects of the structure of paragraphs and texts can influence ability to learn and remember. Work by Meyer (1975, 1977) and Kintsch (1974, 1975) have explored the question of predicting what will be recalled from such materials. Both investigators have developed methods for analysing the structure of texts such that the degree to which the centrality of ideas to the main theme of a passage or a story are revealed. Particular statements may or may not be recalled depending on their relationship to the overall text base.

Further the degree of topical organisation in a text (e.g. Danner, 1976) and the degree to which relevant examples of basic concepts are provided in a text (e.g. Pollchik, 1975) influence ease of learning.

In contrast to external structure, Frase (1973), distinguishes "internal structure" which relates to how a particular body of content is presented. This content structure can be viewed as the web of units of analysis (e.g.symbols, words, concepts) and their interrelations in a body of instructional material (Kingsley,Kopstein & Seidel, 1968; Kopstein & Hanrieder, 1966; Schwab, 1962; Shavelson, 1972; Shavelson & Stanton,1975). In identifying the structure of a subject-matter various units of analysis and various interrelations between units have been postulated. Some of these representational approaches are considered below.

1.2.2 Representations of subject-matter structure

A representation is essentially something that stands for something else and consequently is some sort of model of the thing it represents. A subject-matter structure can be represented in a variety of ways. One approach is to arrange a subject-matter structure hierarchically; the exact arrangement depends on the psychological model underlying the analysis. Ausubel (1963) developed a cognitive theory of verbal learning in which, similar to Gagné's position (1962), knowledge is said to be organised into hierarchies. The apex of the hierarchy is occupied by the most "abstract, general, stable and inclusive ideas". Lower levels are occupied by progressively more detailed, more specific and less stable ideas. In line with this view of subject-matter Ausubel believes that providing passages to be read prior to studying new materials ("advance organisers") helps a learner integrate new material into his existing cognitive structure. Much of the research on advance organisers has used ordinary text materials and has proceeded on an intuitive basis. Selection of an organiser at a higher level of abstractness than the text content is not objectively defined but rather relies upon the competence of the person engaged in the analysis. This competence not only relates to the analysis of text content but also to some judgement of the learner's pre-requisite knowledge.

Gagné's (1962, 1970) taxonomy classified behaviour into eight types of learning which are arranged hierarchically. Instruction is recommended to proceed from the lower to the higher levels (c.f. Ausubel's notions). The idea that the learning sequence may be prescribed by the structure of the subject-matter is considered in the subsequent section (1.2.3). Gagné's scheme has had important instructional implications in that it relates task analysis to instructional design, although Schwab (1964 pp 36-37) has criticised the hierarchical approach of mapping structure with an underlying psychological model.

> "...... if meaning is lost by the absence of the structure appropriate to a body of knowledge, that meaning is seriously distorted by replacing the appropriate structure by some other structure. Yet, in the past twenty years we have warped and revised any number of subject-matters in order to fit them to the bed of views about how and when and under what circumstances this or that is most readily learned. It will be well, if, in future, we thought twice before we modified an item of knowledge in order to fit it to a psychological structure alien to it."

Another methodology for handling content problems is to construct texts which have some clearly defined features and for which adjunct aids can be constructed which map easily upon the content. Musgrave and Cohen (1971) and others (Frase, 1969; Schultz and Di Vesta, 1972) have used this approach. Frase (1969), for instance, generated a text from a concept name by concept attribute matrix concerned with chess. The names of the men (concept name) and the names of the characteristics (concept attributes) were conceived as superordinates naming the rows and columns of the matrix. Cell entries were the values of the characteristics (e.g. the pawn captures diagonally; the queen captures as it moves). It was hypothesised that providing the learner with information about the superordinates would aid learning. Subjects who were informed before reading that there were eight characteristics and what the chracteristics were (the superordinate labels) recalled more of the text on later learning trials than uninformed subjects.

In examining how learning is influenced by the nature of subject-matter material, another approach to the study of organiser-like effects has been the exploration of the effects of inserting relevant questions into texts so learners can evaluate their mastery of the materials. (Anderson and Biddle, 1975; Frase, 1972; Frase and Kreitzberg, 1975; Rothkopf, 1972). Results of these studies suggest that learning and comprehension can be enhanced by written objectives and embedded questions.

A further approach to solving the problem of representing a subject-matter structure derives from content analysis. The universe of content is defined and a category system is developed to partition the content universe. Next, the unit of analysis is determined and numbers are assigned to the units identified. The numbers may represent different categories, rankings or ratings. Content analysis can be criticised as too restrictive an approach in that it focuses on the units of analysis rather than on their interrelations. Any complete conception of subject-matter structure rests at least as much on these interrelations as on the units themselves.

The last approach to be discussed is to represent broadly-defined concepts and their interrelations in a subject-matter as a graph structure (Crothers, 1972; Frederiksen, 1972; Geeslin, 1973, Shavelson, and Stanton, 1975). The points or nodes on the graph represent concepts and the lines represent interrelations between concepts as specified by the syntactic and/or semantic characteristics of the instructional material used to communicate the subject-matter structure. When graphical data of this type is examined with a scaling technique, a visual representation of structure may be obtained. Shavelson and Stanton (1975) claim that this type of representation corresponds to subject-matter structure as understood by many curriculum experts.

1.2.3 Subject-matter structure and learning sequence

In the presentation of instructional material, sequencing has long been assumed to be an important variable. Ausubel (1963 p.213), for example, has contended:

> "Of all the possible conditions that affect cognitive structure, it is self-evident that none can be more significant than the internal logic and organisation of the material."

Sequencing has continued to be regarded seriously by instructional theorists and developers despite a number of methodological problems. Comparisons of random and logically ordered programme sequences (e.g. Levine and Baker, 1963; Payne, Krathwohl and Gordon, 1967; Pyatte, 1969) have failed to reveal the consistent superiority of a carefully organised presentation. Duncan (1972) has suggested that part of the difficulty in designing experiments to answer questions concerning sequencing is that it is often difficult, if not impossible, to find sequences which may be taken as adequate experimental controls. Such control sequences should both be intelligible and yet violate the sequence indicated by the structure of the subject-matter structure.

As Coleman-Stolurow(1975) points out it is difficult to specifically define what is meant by a logically ordered sequence. A variety of different logical sequences may exist, some of which are more effective than others. Leith (1968), for example, found several possible pathways through an Ohm's Law lesson represented in the "ru" matrix by Thomas et al (1963). Some investigators have simply compared structured with random sequences; others have tried to make sure that their control sequences were reasonable learning tasks. Whilst these types of comparison may demonstrate the relative effectiveness of a particular sequence, they do not demonstrate the effectiveness of all sequences considered to be logically ordered.

Another criterion for selecting an instructional sequence has been discussed by Mager (1961). Mager demonstrated that the sequence preferred by the learner may depart dramatically from that considered by the instructor to be inherent in the structure of the subject-matter. If the sequence of information called for by a learner was radically different from that prescribed by the subject-matter it might be inferred that the instructor generated sequence was less meaningful to the learner than it might be. As a consequence of Mager's (1961) paper, considerable interest has developed in "learner-controlled instruction". Learner generated sequences have been shown to be more efficient in some ways than instructor-generated sequences. (Allen and McDonald, 1963; Mager, 1964; Mager and Clark, 1963; Mager and McCann, 1961).

The notion of "learner-control" is similar in some respects to Pask's conception of "free-learning". Most of what we learn comes from being told in oral or written communication. As Pask (1972) points out, any piece of instructional material (e.g. a textbook, a course module or a teaching programme) is based upon a teaching strategy. The teaching strategy is analogous to the learning strategy used by the learner to direct his attention during free-learning except that it is imposed by the instructor rather than generated by the student himself. Pask's measures of performance in the free-learning situation are concerned with the subjective sequencing of information.

Rigney (1978) has stated that cognitive acquisition strategies are concerned with locating and organising subject-matter. In helping a learner build internal knowledge structures these strategies select from assembled material that information judged to be useful and encode it by processing operations that transform the material for long-term-memory storage. In effect, these strategies are transfer operations between the nominal stimulus conditions of a subject-matter and long-term-memory.

Shavelson (1974) makes essentially the same point as Pask (1972) in that he claims that a teacher attempts to communicate a subject-matter structure to the student through verbal exposition,and through written media. Viewed from this perspective a subject-matter provides data from which to infer the cognitive structure of the instructor.

1.2.4 Learning a subject-matter structure

The influential essay by Bruner (1960) has provoked the recognition of the importance of learning the structure of a subject-matter in contemporary approaches to curricula development. Education is being redefined as the building and rebuilding of structures (Renner and Lawson, 1973) and reform in curricula development has moved away from rote learning and computational skills. In the same vein, Piaget (1970) has described how physics advances by assimilating reality to logico-mathematical structures and continually accommodating these structures to new experimental results. Flavell (1963) claims that this structuralist model can apply both to the historical development of a subject and to its acquisition by individuals.

In this conceptual shift to the structuralist view, the following reasons are among those commonly cited. Firstly, structural knowledge is required for a full understanding of the subject-matter; secondly, structural knowledge leads to an aptitude for learning and thirdly, structural knowledge can result in intellectual excitement.

Although some recent research bears on these hypotheses, there is little empirical evidence to support or justify these enthusiastic claims. As discussed earlier, one of the basic methodological stumbling blocks is a clear and objective representation of a subject-matter.

Shavelson (1973) has conceptualised instruction as the communication of a knowledge structure from one source (e.g. a teacher or a textbook) to another source (e.g. a learner). As instruction should be interactive this is an oversimplified view, but the representation has heuristic value insofar as it permits some of the important states through which a structure passes and is transformed to be enumerated (see Fig. 1.2.).

The structure of a subject-matter ultimately resides in journals, advanced textbooks and subject-matter experts. This structure is learned and stored in a teacher's cognitive structure to a greater or lesser extent. The teacher attempts to communicate a subject-matter structure to the student through verbal exposition, through textbooks and so on. The teachers aptitude for his task, therefore facilitates this communication, and finally the student's learning of a subject-matter structure depends upon his aptitude for learning as well as the teacher's efforts.

The communication of subject-matter structure implies an instructional system designed to assist the learner in progressing at a suitably rapid rate from maximum dependence on external information and instruction to an appropriate degree of reliance of information in

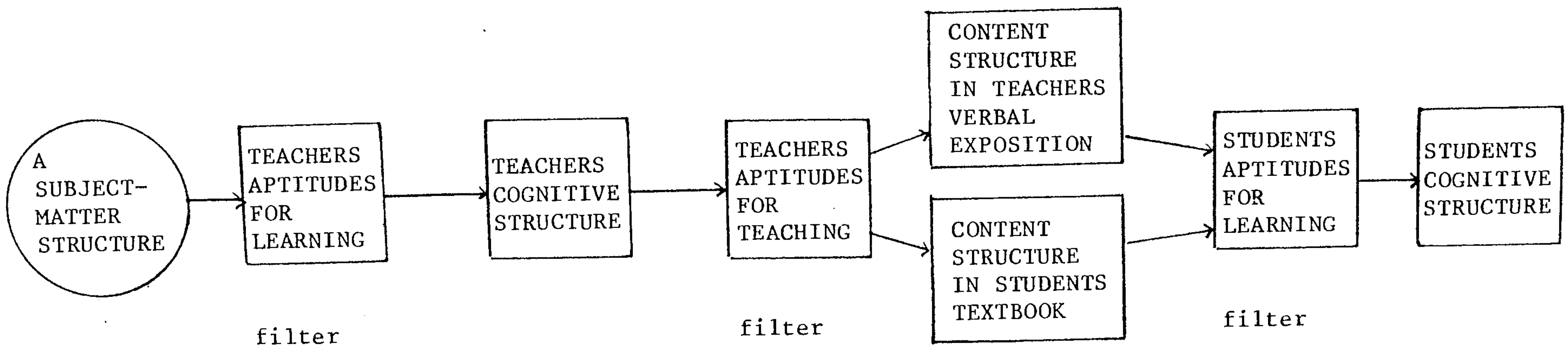

Fig. 1.2 Communication flow of a Subject-Matter structure (After Shavelson, 1974).

long-term-memory (Rigney, 1978). Norman (1976) has distinguished two different instructional strategies. The first strategy is called "linear teaching" and is characterised by the presentation of a cohesive organised structure to the learner and the careful addition of one piece of information after another to the developing structure. The verbal exposition of instructions and content structures in text-books is of this type. In contrast the second strategy is called "web teaching" and is characterised by giving a general overview followed by more detailed overviews, and finally the detailed sub-structure.

The best way of teaching a large body of knowledge would seem to be interconnecting the new information with the existing structure. Consequently, the extent to which the structure in the learner's memory corresponds to the structure in the instructional materials becomes a crucial question. The structure in the learner's memory is known as a cognitive structure and can be viewed as the reverse side of the content structure coin; a textbook, for example, provides data from which the author's cognitive structure can be inferred.

The construct of cognitive structure, examination of methods which purport to measure it and an evaluation of the relevant literature is dealt with in the next section.

1.3 COGNITIVE STRUCTURE

In general, a cognitive structure may be defined as a nonspecific but organised representation of prior experiences (Neisser, 1967). Cognitive structures play an important role in learning and remembering and have been extensively discussed. This chapter restricts itself to a commentary on those aspects of cognitive structure which have implications for learning and instruction.

1.3.1 The constructivist approach

Buhler's (1908) field theory emphasised the relationship between incoming information and semantic "fields", a notion also characteristic of Lashley's (1951) view that the effects of a given input can only be understood in relation to the background of excitation. In other words effective learning is always a function of the relationship between the material to be learned and the learner's currently activated skills and knowledge (Bransford and Johnson, 1972). Learners must make connections between diverse sources of information and do so on the basis of prior knowledge. The interactions of an individual's cognitive structures and processes with incoming information is believed by many contemporary information-processing theorists to result in the acquisition, retention and retrieval of information (Craik and Lockhart, 1972; Craik and Tulving, 1975; Moscovitch and Craik, 1976; Rigney, 1976). Comprehension, therefore, depends upon an individual's abilities to make inferences and assumptions based on their prior knowledge. Some aspects of semantic inference are discussed in the introduction to the experiments of unit 2.

The characterisation of knowledge and the psychological acts of knowing are the concerns of much contemporary cognitive psychology. Anderson and Bower (1973 p.151) state:

> "the most fundamental problem confronting cognitive psychology today is how to represent theoretically the knowledge that a person has; what are the primitve symbols or concepts, how are they related, how are they to be concatenated and constructed into larger knowledge-structures,and how is this 'information-file' to be accessed, searched and utilised in solving the mundane problems of daily living. The choice of a representation is central, since how one handles this issue causes widespread effects throughout the remainder of his theoretical efforts."

Many factors have prompted this renewed interest in these formidable problems, particularly new findings about the structure of human memory (Anderson and Bower, 1973; Collins and Quillian, 1972; Rumelhart, Lindsay and Norman, 1972), and recent studies of computer simulation of natural language relationships (Carroll and Freedle, 1972; Schank, 1972; Winograd, 1972). The issue has often been dealt with as the characterisation of language competence (Chomsky, 1957, 1965; Katz and Fodor, 1963). These linguistic approaches have called the ideal speaker-hearer's intrinsic competence, the grammar of a language. The person who has acquired knowledge of a language has internalised a system of rules that relate sound and meaning in a particular way. In the construction of a grammar of a language, the linguist is in effect proposing a hypothesis concerning the internalised system. The generative grammar of a language specifies an infinite set of structural descriptions each of which contains a deep structure, a surface structure, a phonetic representation, a semantic representation and other formal structures.

Current attempts at generating contextual theories of meaning (Bransford and McCarrell, 1975; Olson, 1970; Perfetti, 1972) recognise, however, that competence cannot be unrelated to performance and what is known must be specified in accordance with the psychological process of knowing. The concern for intentional, social and communicative aspects of speech acts (Searle, 1969: Schlesinger, 1971) are examples of the recognition of the necessity of incorporating psychological characteristics into structural approaches to language.

Previously acquired knowledge can affect learning and comprehension in two general ways (Bransford, 1978). From the constructive perspective comprehension involves the construction of meanings and inferences that may differ from the original message. In contrast the reconstructive hypothesis (Bartlett, 1932) argues that remembering is not simply the retrieval of previously stored information. Rather the assumption is that people remember only the general idea of what was presented and reconstruct the details at time of recall.

Both hypotheses can be incorporated in Bartlett's (1932) succinct statement of the primary act of comprehension in the phrase "beyond the information given". The constructive nature of comprehension requires that an individual need go beyond the explicit information in order to perceive, understand and remember the achieved significance of the constructed meaning. Craik and Lockhart (1972) have argued that there are various degrees to which an individual can go beyond the given information and there are many levels of representation. Memory is enhanced when "deeper" or more complete processing is used. Although the differences in required strategies or knowledge structures associated with the different levels of processing are not yet known, manipulating the subject to "chunk" "image" "cluster" "elaborate" and so on appear to enhance memory. The common mechanism of these various manipulations is that additional cues and information must be provided by the subject to the available stimuli. This application of processing effort is crucial and the act has been labelled "analysis by synthesis" (Neisser, 1967), "effort after meaning" (Bartlett, 1932), "assimilation" (Piaget) or the "click of comprehension" (Brown, 1958).

Recent research in linguistic comprehension has supported the constructivist theory of comprehension which argues that linguistic input is subjected to an abstractive, constructive encoding process. It has been shown, in a number of studies, that subjects do not remember individual sentences or words, but rather they abstract semantic relationships from the descriptive context and integrate these relationships in memory (e.g. Barclay, 1973; Bransford and Franks, 1972; Cofer, 1973; Kintsch and Monk, 1972; Paris and Carter, 1973; Potts, 1972). In other words, the constructivist theory proposes that when a person comprehends meaningful verbal material he educes a cognitive structure for its meaning. Although linguistic transformations of individual sentences play an important role in the initial stages of comprehension, the linguistic input is transformed into a cognitive structure which is a joint function of the input information and the comprehender's knowledge of the world.

Despite the revival and recent popularity of the constructivist position, the advancement to a formal theory is impeded by the poorly-defined characterisations of the cognitive structures acquired by the learner. Some aspects of cognitive structure representations are considered in the next section.

1.3.2 Representations of cognitive structure

Weizenbaum (1976) makes a distinction between theories and models. A theory expresses the structural laws that hold in the object of study at a level of analysis appropriate for the goals and methods of the scientific enterprise for which it is constructed. It does not include aspects that are more concrete than can be verified by empirical observation of the sort indigenous to the science. A model is a concrete embodiment of a theory and because there are many ways in which a given theory may be satisfied, there are many models which are consistent with it. The scope of cognitive theories and models in characterising mental representation, and its referent, the real world, has been discussed by Palmer (1978) who has proposed a view of the situation as diagrammed in Fig. 1.3.

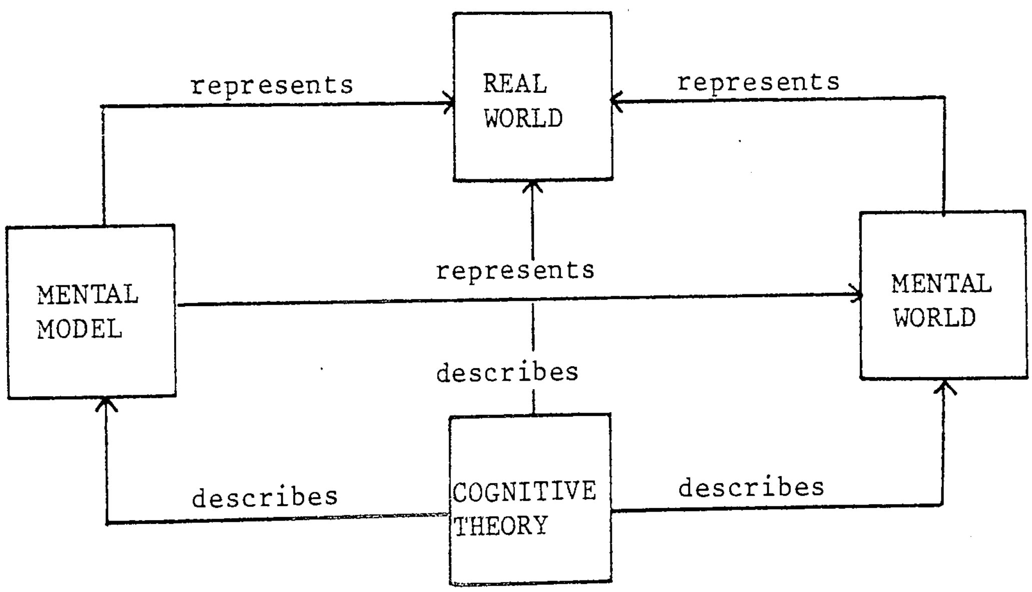

Fig. 1.3. Palmer's (1978) view of cognitive representation

Palmer points out that the "mental world" is some kind of representation of the real world. A cognitive model of this mental world (the mental model) is a representation of a representation of the real world. Consequently, the mental model is a representation of the real world in its own right. This explains why theorists who analyse aspects of the world (the stimulus)rather than the representations of that world (eg Garner, 1974; Gibson, 1966) can make meaningful contributions to cognitive psychology, provided they describe the world with psychological correlates of physical terms.

Semantic memory refers to an individual's general knowledge and may be different from particular memories or past experiences. Tulving (1972) has distinguished knowing from remembering by postulating a semantic and an episodic memory. The influential suggestion was that an episodic task calls upon the subject to remember the occurrence of temporally-dated events or episodes, while semantic memory tasks call upon a subject to retrieve information from his knowledge base of the world. Tulving argued that semantic and episodic memory should be regarded, at least conceptually, as two separate memory systems. Alternatively, it may prove more useful to conceive of semantic and episodic memory as reflecting the operations of different encoding, storage and retrieval processes operating on a common structural data base. As Friendly (1977) observes, to the extent that the latter view is correct, the task of mapping the structure of memory organisation assumes even greater importance.

The nodes or units of semantic memory are not in a simple one-to-one correspondence with the linguistic units of words, phrases, sentences, paragraphs, stories and so on. However, as Wickelgren (1979) observes, there is a corresponding hierarchical structure of increasing complexity in the units of semantic memory. This structure consists of concepts (signalled by words or phrases), propositions (signalled by phrases, clauses and sentences) and schemata (signalled by sentences and larger textual units). The manner in which these semantic units have been organised and represented fall into three major theoretical categories; dimensional models, hierarchical models and network models.

1.3.2.1 Dimensional models

The common notion in these approaches is that items are represented in memory in terms of their values on a set of features (attributes, dimensions, properties, etc.). Sometimes these values in the multi-dimensional attribute space are considered discrete and sometimes as continuous.

Bower (1967) and Underwood (1969) have conceptualised the memory trace as a collection of attributes by which individual items are represented in memory. Other dimensional models of memory structure have placed greater emphasis on the interrelationships among items. Voss (1972) for example, has suggested that organisation occurs along four general structural dimensions, (formal, associative, syntactic and semantic) and he has formulated an analysis of associative meaning in terms of the activation of the encoding of verbal items along these dimensions.

Smith, Schoben and Rips (1974) examined tasks involving verification of semantic relations (e.g. "a robin is a bird") and proposed an attribute model of memory structure to account for the findings. Sets of features, assumed to be ordered in terms of the degree to which they define an item, are compared and the speed of verifying statements depend on this feature matching. In addition, Smith et al (1974) argued that characteristic features (typical but not necessary to define an item) must also be represented in memory insofar as items in a given conceptual category (e.g. bird) would share the same defining features, but would differ in their characteristic features. Rips, Schoben and Smith (1973) provided evidence in support of this dimensional model by demonstrating that the distances between items in the multidimensional scaling solutions of conceptual categories were a good predictor of reaction time in sentence verification tasks.

The distinction between characteristic and defining features is not absolute and as Wickelgren (1979) points out, almost all human thinking uses concepts in which the distinction is blurred. Stated definitions of concepts are almost always higher-level propositions about the concept rather than a partitioning of the concept's constituent features into defining and characteristic parts. The view that concepts are logical functions of attributes probably stems from notions of symbolic logic which has dominated much of the traditional research on concepts and concept learning. Concepts were said to partition the universe of events into two classes (examples and non-examples) and events were analysed into two attributes (relevant and irrelevant). Sets of mutually exclusive attributes form dimensions such that an event could have only one value on that dimension.

Wickelgren (1979) has stated that for some limited philosophical purposes, understanding a concept might be considered equivalent to its set of referents (examples) and their attributes but this is inadequate since it is necessary to know the conditions under which a concept is activated, and these conditions extend far beyond the presence of an example of that concept. Pictures or cues may also activate a concept, and even a limited set of defining attributes of a concept example (e.g. a pig's tail) can activate the concept "pig".

A further ramification of the traditional logical view of concepts has been the assumption that all examples of a concept which possess the criterial attributes have a full and equal degree of membership. Rosch (1973, 1975) has argued that many natural categories are not of this type, but are organised around prototypic exemplars or "best representatives" of the category. Potential category members may vary in their distance from the prototypic exemplars and category membership is not absolute but a matter of degree.

From the instructional angle, several studies have examined individuals' ability to extract prototypical definitions of a concept as a function of the number of training examples and the degree of distortion of the examples from the prototype (Goldman and Homa, 1977; Homa and Vosburgh, 1976; Posner and Keele, 1968). Results suggest that prototypic abstraction and the ability to classify new examples correctly are increased by increasing the number of training examples. When the examples strongly resemble the prototype and each other, a narrow range of degree of distortion of the examples from the prototype facilitated prototype abstraction. However, the best training for generalising the concept is to use more broadly dispersed examples, and interestingly this does not require a greater number of training examples to adequately cover the increased attribute space.

1.3.2.2 Hierarchical models

The principal assumption underlying hierarchical conceptions of the memory store is that the internal representation of items consists of nested groups of items or category sets. Miller's (1956) chunking hypothesis was extended by G. Mandler (1967, 1968, 1970) who claimed that given that the basic unit of the organising system is 5 $\pm$ 2 per set of items, then a hierarchical system of categories can be assembled with an increasing level of complexity and an exponential growth in the system.

Miller (1967, 1969) asked subjects to examine a series of words and sort them into clusters on the basis of "similarity of meaning". He argued for a model in which words are encoded as feature lists but the features themselves are hierarchically organised. Miller demonstrated that a hierarchical organisation of concepts produced definite constraints on the number of subjects sorting a pair of words together, and that the hierarchy itself could be derived by applying hierarchical cluster analysis to these proximity values obtained from a group.

Bower, Clark Lesgold and Winzenz (1969) and Wood (1972) suggest that hierarchical organisation would provide subjects with an efficient retrieval plan, so that access to a memory unit at any level of a hierarchy would provide a high probability of accessing the unit at the next lower level.

The efficacy of hierarchical organisation of recall has received considerable empirical support. Cohen and Bousfield (1956) found improved recall of a categorised list when the list categories form a hierarchical structure than when they are independent. When the list is presented in a way that makes its hierarchical structure more apparent, facilitation of recall also occurs (Bower et al, 1969).

J. M. Mandler (1979) has contrasted categorical and schematic organisations in memory. She has argued that categorical organisation refers to the cognitive structures, hierarchically arranged, that govern understanding of the relationships among superordinate, subordinate and co-ordinate classes. This kind of organisation includes both lists of items that belong to a particular category and to the more abstract models of class-inclusion relations which enable inductive and deductive thinking. Because most sets of objects can be classified in a variety of ways, categorical organisation is highly flexible and this flexibility is the basis of individuals problem-solving ability. Like a categorical organisation, a schematic organisation is a cognitive structure but unlike categorical organisation, the structure is not based on class membership and similarity relationships among class members. Rather it is a spatially and/or temporally organised structure which is formed on the basis of past experiences with objects, scenes or events. A schema consists of a set of expectations about the appearance of things and/or the sequence in which they occur. The units of a schema await occupation in any given instance by values which have varying degrees of probability of occurrence. Consequently, the less predictable a value that may occupy a schematic unit, the more general the schema, and schema vary greatly in their degree of generality.

Scene schemata are cognitive representations of perceptual expectations when viewing or entering a scene and may be distinguished from event schemata which are expectations about what will occur in a particular situation. Little theoretical work has attempted the specification of scene variables although Mandler and Johnson (1976) and Mandler and Parker (1976) have suggested that scene schemata are hierarchically organised in that each of the variables has more detailed schemata embedded in it.

Event schemata may also be described as hierarchically organised sets of expectations and, in common with all others, vary in generality. Schank and Abelson (1975, 1977) have labelled some specific schemata "scripts". These scripts are typical events that are expected to occur in specific situations (e.g. going to a restaurant) and these authors have used the term "plans" to refer to more general tentative event schemata. Story schemata (Mandler and Johnson, 1977; Rumelhart, 1975) attempt to specify the general form and sequence of the events that occur in simple stories.

J. M. Mandler (1979) has suggested that both schematic and categorical organisations are hierarchically arranged cognitive structures that can be used for the purposes of encoding and retrieval.

1.3.2.3 Network models

In hierarchical models, a given node may only be connected to nodes one generation above or below. In a network the restrictions of hierarchical structures are removed. Network models represent word concepts as nodes and relationships among words as links connecting pairs of nodes. Any node may be linked to any other, and the links may be binary (representing a relation, present or absent) real valued (strength of relation) and/or labelled (type of relation).

The earliest network models stemmed from attempts to apply structural analysis to performance on word association tasks (Guilliano, 1963; Kiss, 1967, 1969; Pollio, 1966). Although the idea of a memory based on the notion of associations dates from Aristotle, it is only since Quillians introduction of a self-contained semantic net formalism (Quillian, 1968, 1969) that this approach has gained increasing acceptance as a propositional representation in understanding and reasoning systems. Network models have been widely adopted in computer simulations of human memory and the enthusiasm they have engendered is reflected in Shapiro's (1971) view of the distinctive characteristics of semantic nets:

> "All the information about a given conceptual entity should be reachable from a common place (where) a conceptual entity is anything about which information can be given. That is anything about which one can know, think, or believe something; anything we can describe or discuss or experience."

Anderson (1972) developed a precise theory of free recall based on a simple associative network embedded in a computer program dubbed FRAN (Free Recall by an Associative Net). FRAN has proved competent at reproducing many aspects of human behaviour in free-recall situations. In particular, the simulation shows a typical learning curve, a serial position function, and organisation phenomena. However, on the whole FRAN recalls less and shows less category clustering than humans. The reasons for this is that FRAN's network does not distinguish among items linked by different types of relationship and Anderson (1972,1976) argued for the necessity of relation-labelled links in a network.

Human Associative Memory (HAM) (Anderson and Bower, 1973) and ACT (Anderson, 1976) were successive attempts to develop systems with wider capabilities than FRAN whilst retaining the capabilities of the original system. Both HAM and ACT are more ambitious than FRAN in that they are designed to simulate both the structure of human knowledge and at least some of the processes that act on that structure. In order to attempt to achieve these ends, Anderson's work has moved away from a simple associative framework to more relation-labelled network links and an increased emphasis on process. Other memory models employing such relational networks have been proposed (Kintsch, 1972, 1974;

Norman and Rumelhart, 1975; Quillian, 1968, 1969; Rumelhart, Lindsay and Norman, 1972; Schank, 1973; Simmons, 1973).

Quillian (1968) proposed a general model of semantic memory which is directly configured in terms of a labelled associative network, but has a number of the features of a hierarchical structure. In 1969 Quillian extended the model into a theory and a computer program was developed to deal with the understanding of continuous text. The model consists of a network of nodes connected by different types of links. The nodes in this network represent clusters of information and in its simplest form represents a concept whose meaning is determined by a list of properties which are, in turn, other concepts (nodes).

The various relationships between nodes are represented by lines, any number of which may connect two nodes. Some common relationships are superset, subset, attribute, and part-whole. By interrelating these concepts in various ways a new concept can be formed. For example, using a similarity relation:

> "if one knows a toad is like a frog and that a frog is an amphibian, then one can infer with some uncertainty that a toad is an amphibian."
>
> (Collins and Quillian, 1972, p.323)

Class inclusions play a central role in Quillian's (1969) model in that every node contains a mandatory pointer to its immediate superset node. Further, property values related to a concept are assumed to be stored at the highest node for which the property value applies to all descendent nodes. It is assumed that only the general fact is stored and others are inferred by tracing the superset links. This assumption has been shown to be consistent with reaction times in a sentence verification task (Collins and Quillian, 1969, 1970, 1972). (Section 2.6.1 discussed this view of semantic memory structure in relation to set-theoretic approaches (e.g. Meyer, 1970) in greater detail).

1.3.2.4 Relations between the models of memory structure

A hierarchical structure is a special form of network which has restrictions in allowable links. Viewed from this perspective Quillian's network model can be seen to display many features of a hierarchical system. To trace all reachable paths from a given node generates a structure of progressively finer detail whereby new concepts are linked to their superset nodes and the properties are stored hierarchically. As these local hierarchies are embedded in the overall memory system, it may be that larger more general domains may appear to be hierarchies while restricted areas may appear to be networks.

Further, it is apparent that feature-list representations can be constructed into network representations in which items appears as nodes and the features are the labelled links between nodes (Fridja, 1972). Schubert(1976) has argued that the graphical symbolism used by semantic net theorists is a variant of traditional logical notation. It may be that the three representational approaches to cognitive structure can ultimately be reconciled.

1.3.3 Mapping cognitive structures

The concept of the semantic proximity of two words has been a major analytic tool in studies of verbal organisation in memory. This concept neatly meshes with geometrical representations of cognitive structure and into feature-overlap views of similarity of meaning. A similarity method of rating is the most direct technique for measuring semantic proximity, but the extent to which words are clustered in free-recall (Bousfield, 1953) or in sorting tasks (Miller, 1969) has also been used. Rapaport (1967) has devised a rapid method of obtaining proximity measures by asking subjects to construct trees in which vertices are the words and edges are the relations between words. The most widely used technique, however, has been the word association test in which the degree of overlap of response hierarchies is used as the measure of the semantic proximity of the stimulus words (Deese, 1965).

The convergent validity of these three methods of mapping cognitive structure have been investigated. Henley (1969) found in an investigation of the semantic structure of animal terms, that similarity ratings and word association methods gave similar results, although a clustering method did not. Similar results were obtained by Anglin (1970) with free-recall and sorting experiments, although a word association test was not successful in revealing the structural relations among the words. Rapaport and Filenbaum (1972) found that tree construction and sorting procedures yielded essentially the same results, and using a different semantic domain, they found that the tree-construction test and a pair similarity ranking procedure gave similar results for group cognitive structure.

The group cognitive structure for a set of mechanics concepts has been shown to be well represented in a three-dimensional spatial model (Johnson, Cox and Curran, 1970), and also by a non-rooted hierarchy (Johnson, Curran and Cox, 1971). Mechanics concepts are particularly useful in investigations of cognitive structure because their meanings can be defined simply in terms of a few basic concepts. Preece (1976) observes that, in addition, much is known about the properties of mechanics concepts as stimuli in continued word association tests. A positive relationship has been found between response availability and knowledge of mechanics as measured by problem-solving tests or course grades (Johnson, 1965, 1967; Shavelson, 1973).

Two methods of analysis have been used in extracting structure from measures of similarity. The first is a clustering procedure that yields a rooted hierarchy representation (Johnson, 1967) and the second is multidimensional scaling which yields a spatial representation of the structure (Kruskal, 1964). Rapaport and Filenbaum (1972) have pointed out that the clustering procedure is appropriate if the underlying structure is one of taxonomic class inclusion while the multi-dimensional scaling technique is appropriate to linear structures. However, Holman (1972) has suggested that these two models of semantic proximity are incompatible.

In some semantic domains neither spatial nor rooted-hierarchy structures appear to be a priori appropriate and in these cases a graphical method of analysis (e.g. Waern, 1972) may be appropriate.

1.4 COGNITIVE STYLES AND LEARNING STRATEGIES

The most influential post second-world-war investigation of thinking has been the work of Bruner, Goodnow and Austin (1956) who reported a classical series of experiments and introduced several important innovations. One of the main achievements was the inference of strategies from observed behaviour and verbal reports. Bruner et al's largely operational conception of strategies as simply an observed pattern of decisions highlighted the importance of considering how strategies come to be adopted and how they may affect thinking. An important point apparent in the Bruner et al investigation was that though different individuals set about solving a problem in different ways, the variation was quite limited. With repeated performance of the task a few novel strategies were generated but most strategies were mixes of the few basic ingredients specified by Bruner et al (Lewis and Pask, 1964).

Shouksmith (1970) has suggested that strategies which recur consistently within the same individual make up what may be referred to as the cognitive style of the individual. Warr (1970) has described cognitive styles as habitual ways or modes of dealing with information about oneself and one's environment which are to a large degree independent of the content of the information being handled. This emphasis on the structure rather than the content of thought is common to all theory and research on cognitive style. Although this concern for cognitive style is not new in modern psychology, increased interest in the analysis of cognitive behaviour has prompted more attention being paid to cognitive style in recent publications (Kogan, 1976; Landfield, 1977; Goldstein and Blackman, 1978).

The attraction of the concept of cognitive style lies in two features of thought which have traditionally preoccupied psychologists interested in thinking, namely control and direction. By definition, these controlling and directional functions are inherent in the cognitive style concept. The question of how ideas follow one another was one of the main issues for Associationism and structuring was, in the Gestalt approach, a critical element of productive thought. A complete analysis of thinking must include how thought is directed. However, in part a person's thinking about a problem may be directed by the nature of the problem itself and a given type of problem may encourage the development of more than one technique or solution strategy. Wood (1978) has pointed out that the effective problem-solver has a range of potential experiences upon which to draw, and in the attempt to solve a problem his behaviour furnishes fresh data from which new representations and manipulations of the problem-space are invented.

Miller, Galanter and Pribram (1960) fill the gap between cognition and action with an "image" which includes everything learned and all the "values" a person has. The image is used by an individual to form plans defined as "any hierarchical process in the organism that can control the order in which a sequence of operations can be performed." The plan controls behaviour and the image being peculiar to the individual provides what might be seen as essentially cognitive style in the development of these plans.

Miller et al (1960) define strategies as reflecting style factors in the direction of planned behaviour and distinguish "tactics" which reflect the short-term set of responses to a given situation (although they must also be influenced by an individual's strategies or personal characteristics). Shouksmith (1970) has suggested that long-term strategies as defined by Bruner et al (1956) may be equated with cognitive style factors. In contrast, short-term strategies are seen as referring to behaviour guided by the situation. Underwood (1978) has observed that individuals with particular cognitive styles may use particular strategies although much of the work on strategies has focused on strategies of very limited generality (Baron, 1973). Baron (1978) has postulated the existence of a set of general strategies which underly intelligent behaviour.

Pask (1972) has claimed that an individual learns in a way that depends upon his cognitive style, and that the instructional importance of cognitive style has not been commonly recognised. Pask refers to a learners cognitive style as his cognitive competence and points out that although strategies are important, it is also necessary to consider the learners competence in executing strategies of a given class. Certain types of strategy call for certain types of competence. The view adopted is that effective learning can only take place when the individually-selected (learning or teaching) strategy is matched to the students existing competence.

The central core of evidence relating to learning style is due to Bruner et al (1956), Guildford (1956), Kagan (1965) (the impulsive/ reflective distinction) and Witkin et al (1975) (the field dependent/ independent distinction). More recent work includes investigations of reading style (Thomas, 1971), logical problem solving style (Dirkzwager, 1974), decision style (Strub and Levit, 1974; Tversky and Kahneman, 1974) creative reasoning style (Elshout and Elshout, 1969) and design style (Hankins, 1974). Newell and Simon's (1972) protocol investigations on thinking and Landa's (1974) experiments on logic and language learning clearly reveal distinct styles. In addition to these laboratory demonstrations of cognitive style, differences in the way people perceive, explore and learn about their environment have been reliably detected by Lynch (1960) and Glanville (1974).

Pask (1969) distinguishes between performance strategies concerned with the execution of a skill and the learning (or teaching) strategies that build up performance strategies. Performance strategies have been studied with respect to a great many tasks and characterise a wide spectrum of mental processes from the context of a perceptual-motor skill through the hierarchical organisation of problem-solving procedures to insightful activity. The next section considers learning strategies in greater detail.

1.4.1 Learning strategies

Following the conceptual distinction, made in the late 1950's, between the presented nominal stimulus and its encoded functional counterpart, it was recognised that the associations between the stimulus and response were neither as simple nor as direct as the traditional associationist verbal learning paradigm had supposed. The recognition that the learner played an active role in transforming instructional material has led to the current model of the learner as a self-determining individual who processes information in complex ways and who learns through the active use of cognitive strategies. Cognitive learning strategies are required by an individual in order to select and govern his behaviour in the learning situation (Gagné and Briggs, 1974).

Learners must be able to identify relevant portions of instructional material, apply techniques to comprehend and retain the material, and subsequently recall and use the acquired information under appropriate circumstances (Dansereau, 1978). Acquisition strategies (Rigney, 1978) are concerned with facilitating the assembly of appropriate mediating knowledge structures. These type of learning strategies (Pask, 1972) operate when the learner is unable to generate the required performance strategy all at once. Instead he directs his attention to various sub-tasks and musters subroutines that build up performance strategies bit by bit. In the free-learning student, this process is carried out according to a learning strategy which may be innate or acquired and which can be imposed externally by an instructional system.

Pask maintains that both learning and performance strategies entail breaking goals into subgoals and applying mental subroutines to achieve the subgoals concerned. The difference between the two types of strategy lie in the domain upon which they operate. Whereas the performance strategy solves problems posed by states of the environment, the learning strategy solves the problems posed by deficiencies in the current repertoire of relevant performance strategies. In other words performance strategies are solutions produced by a learning strategy. Rigney (1978) has called those strategies that are concerned with locating and organising subject matter, "cognitive acquisition strategies". By selecting from the instructional material that information judged to be useful and applying techniques to comprehend and retain the material, it is apparent, as Rigney (1978) points out, that these strategies are transfer operations between nominal instructional material and long-term-memory.

Strategies for retention and retrieval of information have received less attention than acquisition strategies probably because the primary instructional emphasis is on inducing learners to acquire information and skills. Since there may be fundamental differences between the storage-processes in long-term-memory for semantic information, episodic information and motor information, Rigney (1978) has suggested that avoiding interfering conditions and maintaining storage (by appropriate reacquisition or review activities) might be too general a conception of retention strategies. Since retrieval may occur during acquisition or retention stages of learning, Rigney has further suggested that retrieval during acquisition is likely to require less processing capacity, having been freshly stored, whilst retrieval that occurs after longer intervals after acquisition would require more processing capacity, even to the extent of reconstructing knowledge from other related knowledge.

In contrast to strategies which operate directly on the materials (primary-strategies) Dansereau (1978) has distinguished "support strategies" which allow the primary strategies to flow efficiently and effectively. Such support strategies could include techniques for establishing an appropriate learning attitude, methods for coping with loss of concentration due to interfering conditions, and techniques for monitoring and correcting the ongoing primary strategies.

Learning strategy research has primarily focused on assessing the effects on performance that result from manipulation of specific strategy components and these are considered in the next section. Much less work has been done on assessing more generalised training (as in a skills course) although Dansereau et al (1975) have investigated combinations of strategies in a systematic way on text processing.

1.4.1.1 Strategy components and performance

The studies to be discussed are concerned with four primary strategy areas; identification, comprehension, retention and retrieval; and one support strategy area: concentration. These areas have been previously reviewed in more detail by Dansereau (1978).

In the identification area, studies have demonstrated the flexibility of individuals in the processing of information. The identification and selection of the stimulus materials has been manipulated by varying subjects anticipated recall requirements (Butterfield, Belmont and Peltzman, 1971; Jacoby, 1973) or by varying conditions of monetary rewards (McConkie, Rayner and Mayer, 1971; McConkie, Rayner and Wilson, 1973).

In the comprehension and retention strategy areas a number of studies have attempted to indirectly change the learners comprehension and retention activities by including pre- post- and interspersed questions (e.g. Mayer, 1975; Richards and Di Vesta, 1974) or pre- and post-supplementary organising materials (e.g. Ausubel and Youssef, 1966; Frase, 1969; Gay, 1971) or by varying conditions of monetary rewards (e.g. McConkie and Meyer, 1974; McConkie and Rayner, 1974).

Positive effects on performance have also resulted from more direct manipulations of comprehension and retention strategies. Instructions to form mental images (e.g. R. C. Anderson, 1970; Rasco, Tennyson and Boutwell, 1975), instructions to restate material in learners own words (Del Giorno Jenkins and Bausell, 1974) and instructions to reorganise the incoming material (Di Vesta, Schultz and Dangel, 1973; Frase, 1973) have all improved recall.

A number of studies have demonstrated that retention of unrelated words or word pairs can be enhanced by giving learners brief instructions on mnemonic techniques (e.g. Bower and Reitman, 1972; Lowry, 1974; Weinstein, 1975).

Approaches that instruct learners to use systematic search strategies as aids to memory retrieval have not been widely investigated though Dansereau (1978) suggests that the problem-solving strategies explored by Newell et al (1958) could provide a useful base for the development of these direct manipulation techniques.

In the support strategy area of concentration, a number of studies have attempted to instruct learners to talk to themselves in a constructive positive fashion as a means of coping with distractions and anxiety (e.g. Meichenbaum and Goodman, 1971; Patterson and Mischel, 1975). Alabiso (1975) has attempted to improve concentration with behaviour modification techniques. Both the instructional and reinforcement approaches have increased the volume of task-related behaviour.

Dansereau (1978) has criticised most studies which have manipulated strategy components because of their use of highly artificial tasks and materials, which makes it difficult to generalise the results to more meaningful tasks. This criticism is an echo of earlier broader criticisms based around the "artificial" laboratory setting as the location for investigations of "real world" behaviour (e.g. Neisser, 1976; Newell, 1973a). As Underwood (1978) observes, these are interpretive errors since the learner's cognitive structures, which transform and encode the experimenter's information, are the same whether he is sat in his garden or sat by the laboratory bench. The criticism does have some justification, however, insofar as the variable strategies which a learner might display could change in the laboratory setting.

1.4.1.2 Learning strategies and artificial intelligence

Since the early attempts in the late 1950's to build computers that could carry out tasks requiring human intelligence, the field of artificial intelligence has expanded to include a wide range of approaches and methodologies. The programs designed to carry out these tasks have become increasingly sophisticated (Bobrow and Collins, 1975;Schank and Abelson, 1975; Winston, 1977) but all must have a representation of the knowledge they involve and some mechanisms for manipulating that knowledge for certain purposes (Findler, 1979). The artificial intelligence field is evolving very rapidly and is providing a new basis for analysing cognitive processes, such that the structural and procedural mechanisms postulated can contribute to theories about human-problem-solving, planning,representing knowledge, and understanding text.

These developments have clarified some aspects of what is exactly meant by "understanding" texts, instructions, problem-solutions and so on. As Brown, Collins and Harris (1978) point out, it has been recognised that "understanding" requires different kinds of knowledge not explicitly referred to in the instructional materials. In addition, the importance of strategies for governing how this implicit knowledge should be used is acknowledged in the development of appropriate structural models.

One of the most rapidly developing areas is the construction of associative networks to serve as the knowledge base of programs that exhibit some operational aspects of understanding. Such programs can carry out things like paraphrasing, abstracting, answering questions on the basis of commonsense reasoning and drawing inductive and deductive inferences. Some aspects of network models have been considered previously (1.3.2.3).

The advent of computer programmes designed to simulate complex intellective processes is, as J. M. Mandler (1978) observes, introducing new vocabulary, new emphases and new theory into classically-conceived psychology.

1.4.2 Aptitude-Treatment Interaction (ATI) research

If a student learns in a way that depends upon his individual cognitive style and the strategies he adopts, then it follows that the outcome of learning will differ according to whether the instructional techniques are adapted to suit the learner's idiosyncrasies. For the experimental psychologist, the problem of adapting instruction to the individual reduces to the search for significant disordinal interactions between alternative treatments and learner characteristics, i.e. to develop alternative instructional programs so that optimal instructional payoff is obtained when individuals are assigned differently to the alternative programs. Many instructional psychologists have suggested that no one instructional technique can provide optimal learning for all students (e.g. Bloom, 1968; Cronbach, 1957, 1967; Gagné, 1967; Glaser, 1967).

Since Cronbach's (1957) emphasis on the need for a rapprochement between "individual difference" and "task parameter" approaches, ATI research has enjoyed increasing popularity. The two streams of research, identified by Cronbach, has been distinct in their objectives and in their methods of investigation. The "individual difference" approach has considered the relationship between individual differences in performance on ability tests and performance in learning tasks. These studies have been correlational in the sense that they have typically involved no treatment manipulations and have been concerned with predicting variation within the single treatment used. The "task parameter" approach has attempted to control performance by manipulating task parameters in accordance with information processing notions. These studies have been typically bivariate (one independent and one dependent variable) and can be considered to be experimental in the sense that an individual variable, task characteristic is manipulated. Cronbach (1957) suggested that multivariate experiments which are designed to measure organism "state" variables (e.g. abilities) and to manipulate task parameters (treatments) are of prime theoretical importance.

Pask has argued that learning and performance strategies call for the execution of mental sub-routines which are relatively permanent features of the mind. The efficiency of different sub-routines varies from person to person and the distribution of evaluations of efficiency of these sub-routines is what Pask refers to as the subjects competence (or competence profile). In order to assess a students competence it has been argued that multi-aptitude and ability tests provide the requisite data (Guilford, 1956). The "structure of intellect" model can provide specific estimates of differential competence but, in general, although ability tests may be expected to sample the efficiency of common sub-routines; process constructs entail entries in many of Guilfords cells. Melton (1967) has suggested that hypotheses about individual difference variables should be framed in terms of the process constructs of contemporary theories of learning and performance.

Further, Melton has pointed out the inadequacy of measuring individual differences in performance in learning tasks as a function of the almost infinite variety of operationally defined variables in these tasks. Nor is it enough to know that a performance is heavily weighted with whatever is measured in a reference test. Most research on ATI has adopted one or both of these limited approaches.

The results of several decades of concern with the individualisation of instruction has led to a mass of data that is difficult to render meaningful or even replicate. (Berliner and Cahen, 1973; Cronbach and Snow, 1969; Di Vesta, 1973). After analysing 90 research studies, Bracht (1970) unhelpfully observes:

> "It seems that the two major factors in the occurrence of ATI are the nature of the alternative treatments and the selection of personological variables."

He does, however, make two interesting points. Firstly, in a number of studies, the analysis of an interaction effect was often an afterthought. Secondly, alternative treatments in many studies were only some minor modification of an original instructional program. Consequently, what is needed is hypothesis-oriented research in which the selection of individual difference measures and treatments is based on specific hypotheses about their interactions (Berliner and Cahen, 1973; Salomon, 1972).

The research aimed at demonstrating relationships between learning performance and intellectual abilities (e.g. Dunham, Guilford and Hoepfner, 1968; Fleishman, 1972; Frederiksen, 1969) has generally supported the conclusion that the pattern of abilities related to learning proficiency depends on specific task conditions, but the view that performance is mediated by cognitive strategies which are a function of task characteristics and the state of the organism is increasingly acknowledged (Frederiksen, 1972).

Labouvie, Frohring, Baltes and Goulet (1973) proposed that interactions between ability measures and learning tasks reflect the use of common strategies, and demonstrated treatment and trial-related shifts in the respective contributions of memory and general intelligence to free recall learning, under different conditions of subjects' reliance on a conceptual strategy (subjective organisation). However, a replication and extension of the experiment (Labouvie, Levin and Urberg, 1975) failed to produce any strategy-related shifts.

Labouvie et al (1975) argue that the problem of failing to replicate results can be overcome in research on aptitude-treatment interactions by capitalising on "powerful experimental task parameters". Perhaps this is true but the ATI enterprise has generally not been as productive as might be intuitively assumed, although a recent overview by Tobias (1976) suggests conservative optimism.

If, in the future, the happy eventuality of exploiting individual differences in the optimisation of instruction is to be realised, then a sound theoretical basis with respect to cognitive processes, abilities and the external variables affecting them must be developed. In this context, the ATI approach must be correct insofar as it is merely an operational expression of adapting instruction to the individual. The interpretation and implementation of the approach is where much ATI research has run into problems.

PART 2

PART 2 - THE EXPERIMENTS

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If effective learning occurs when new information is integrated into prior knowledge, then it is apparent that learning must involve comprehension. Comprehension can be viewed as relating new experience to the already known (Smith, 1975). In particular, the learning process implies a reorganisation of that aspect of cognitive structure that is often referred to as memory. All of the experiments reported in Part 2 of this thesis attempt to highlight the dynamic processing of new information in terms of an individual's existing knowledge and skills.

Six experiments are described and they are organised into two units, each comprising three experiments. Each experiment is presented in the standard format and each unit is preceded by an introduction and followed by a general discussion. The two units are clearly distinguishable both from the methodological approach adopted and the aspect of the problem area tackled. The first unit approaches the problem of representing a subject-matter structure by constructing experimental materials on which learners can impose clearly defined alternative modes of organisation. The selection (by the learner or experimenter) and the effects of these organisational modes on performance during the acquisition and recall phases of learning are investigated in experiments 1, 2 and 3.

In the second unit, experiments 4, 5 and 6 investigate more directly how new information is incorporated into what the learner already knows. In these experiments a set-theoretic representation of categories in a syllogistic reasoning task is used as a means of examining some aspects of how learner's incorporate new categories.

2.1 INTRODUCTION TO UNIT 1

2.1.1 The concept of memory organisation

Bousfield (1953) randomly presented words from different conceptual categories and found that subjects recalled them grouped or clustered by category. Following this pioneering work organisation in the form of category clustering and subjective organisation had formed the major enterprise in organisational research for two decades.

Herriot (1974) has observed that the uses of the term "organisation" have differed in accordance with the traditions of work they exemplify. Many of the operational definitions that have been proposed are extremely circumscribed and paradigm specific. Furthermore, as Pellegrino and Ingram (1979) point out, most definitions focus on the characteristics of some external product and do not distinguish organisation as process and organisation as product of process. Mandler (1967), for example, has stated that a set of objects or events are organised when a consistent relation among the set members can be stated. Tulving (1968) has also emphasised the characteristics of product rather than the process giving rise to the output structure. Tulving regards the subject's output order at recall as being the crucial evidence for organisation and has contrasted a "weak" and a "strong" definition of organisation. Organisation in the weak sense is independent of prior familiarity with a set of input items and merely refers to consistent discrepancies between input and output orders. In the strong sense organisation is governed by semantic or phonetic relations among the items, or by the subjects' prior acquaintance with the items. However, not all conceptions of memory organisation have ignored the product/process distinction. Voss (1972) has stressed that organisation is localised within an organism and is a process that intervenes between input and output. Pellegrino and Ingram (1979) have viewed organisation as a storage or retrieval process (or set of processes) used in a strategic attempt to maximise memory performance. These authors view strategies as general tactics which operate at coding (input) and retrieval (output) which may consist of one or more elementary processes.

The concept of organisation is closely related to the distinction between nominal and functional units. Although material may be presented as items, it cannot be assumed that subjects code item by item, and may in fact code items in such a way to make the functional unit larger than the nominal unit. This "coding by unitisation" may involve several basic processes such as search, comparison, rehearsal, etc. (Pellegrino and Ingram, 1979). Empirical support for the existence of this unitisation strategy has come from research directed towards the phenomena of clustering and subjective organisation. These two areas of analysis of organisation in recall have been characterised by Herriot (1974) as the "reductive" and "elaborative" traditions. The reductive tradition stresses the connections beween the degree of coding of relations and amount recalled, while the elaborative tradition seeks to show how subjects code relations between nominally unrelated items. Tulving (1972) was the first to demonstrate the "subjective organisation" phenomenon, based on the observation of non-random recall order and increasing stereotypy over successive trials. Sternberg and Tulving (1977) have pointed out that "subjective organisation" may be used either to refer to a psychological process or the measure of the extent to which the process is observed in observable behaviour.

2.1.2 Output organisation in free recall

Although there is little doubt about individual's use of the general unitisation strategy in the acquisition and retention of conceptually structured lists, debate exists over the selection of an appropriate measure of the extent to which such a strategy has been employed. The number of such measures and their various characteristics has been claimed to be one of the reasons for the recent decline in interest in research relating to measured memory organisation. Tulving and Bower (1974) suggest that the clustering method may be useful only when used as one of several converging operations.

Further, organisation has been ascribed little or no role in determining memory performance in the influential levels-of-processing approach, originally proposed by Craik and Lockhart (1972). Battig and Belleza (1979) have argued that the levels-of-processing position concentrates on research paradigms and techniques that violate virtually all of the standard conditions that characterise organisation in free-recall. In its emphasis on individual items, the levels-of-processing paradigm may well have minimised the possible involvement of organisational processes. In order to develop a satisfactory account of human memory, Battig and Belleza (1979) have claimed that the levels-of-processing approach must eventually incorporate organisational process.

To understand the processes underlying clustering and recall rather than to focus on clustering measures per se appears to be the way in which contemporary memory organisational theory can increasingly accept less strict operational concepts and expand to embrace a more cognitive perspective, stressing knowledge, strategies and expectations.

2.1.3 Sequential effects

In typical free recall, the subject is instructed to recall as many items as possible from a specified set without regard to order. Emphasis is on the development of stable recall structures, in the absence of any implicit or explicit structure at input. By presenting items in a constant sequence, structure may be provided at input and, under certain circumstances, individuals may make use of the contiguous structure of input materials. A number of studies have demonstrated that individuals have a strong tendency to use the item sequences as the basis for structuring recall (e.g. Jung and Skeebo, 1967;G.Mandler, 1969a,b; Postman, Burns and Hasher,1970; Wallace,1970) and this results in superior recall. This type of organisation has been termed "seriation" by G.Mandler (1969) who has demonstrated that it may be used almost as frequently as category clustering. Pellegrino and Ingram (1979) have claimed that adopting the seriation strategy may be an efficient storage and retrieval process when conditions allow for its use. Seriation appears to be preferred whenever memorial and processing capacities are not overloaded (Mandler and Dean, 1969) although Mandler and Barsalou (1978) have demonstrated that subjects can,regardless of personal preferences, equally well use serial or categorical organisation at recall when instructed to do so. Although subjects recall slightly less from categorised lists when the item sequence is random rather than blocked (Cofer, Bruce and Reicher, 1966) it appears that adults can typically uncover the categorical structure and reorganise their recall accordingly. G. Mandler (1979) has observed that whether or not an individual will discover a categorical structure of the input list depends upon his expectations, knowledge and intentions. The use of serial structures depends in part, as G.Mandler (1979) points out, on the fact that contiguity in the input events is easily discernable.

The extent to which recall order reflects input order appears to be different for stories and categorised lists. Mandler and Johnson (1977) and Stein and Glenn (1979) have demonstrated that output order strongly reflects input order for stories, especially for well-structured stories. If stories are presented randomly recall decreases (Thorndyke, 1977) and output order does not reflect the schematic order (Stein and Nezworski, 1978) (the "schema" concept has been discussed in 1.3.2.2). Under random presentation individuals seem unable to discover the input structure, whereas if stories are presented in an irregular but not completely random fashion, individuals tend not to follow the input order but reorganise their output to follow the schematic order (J. M. Mandler, 1978; Stein and Nezworski, 1978).

J. M. Mandler (1979) has pointed out that categorical organisation depends solely on the connection between items and their superordinate categories whereas schematic organisation depends on the relationship between the items. Activation of the relevant schemata does not occur when a story presentation is random, whereas adults can typically discover categorical structure when list items are randomly presented. Of course, as G. Mandler (1967) observes, individuals frequently utilise the serial structure of input materials (possibly because it is easily discernable) and although the seriation and categorisation bases of organisation are often incompatible (Postman, 1972), both can give rise to superior recall.

2.1.4 Organisation of instructional materials

A number of approaches have been used to attempt to investigate how learning is influenced by the sequence and organisation of instructional materials. One approach, well-represented in the literature, has been to provide information about a text's organisation or structure to learners. These adjunct or organisational aids are generally in the form of outlines, headings or topic sentences and are designed to facilitate recall by explicitly highlighting the relationships among the informational units of the text (these units being variously defined). Superordinate ideas can be used to facilitate the recall of subordinate information. Much of this work is, therefore, broadly concerned with investigating how learning can be enhanced by providing students with instructional objectives about what they should learn from a text. Providing explicitly stated objectives to students prior to instruction has been shown to increase the effectiveness of training (Mager and McCann, 1961). In Postman's (1964) Type II incidental learning studies, intentional learning is defined in terms of the materials that are relevant to directions that have been given to a subject prior to training. Rothkopf and Kaplan (1972) have explored the role of specificity of objectives in determining both intentional and incidental learning from text. Dee-Lucas and Di Vesta (1980) have argued that learner-generated organisational aids cause a focussing of attention such that a subset of the text is learned very well (intentional learning) but at the expense of other (incidental) information. This selective attention interpretation of the effects of learning objectives has also been suggested by Melton (1978). Research relating to questions interpersed at various points in texts (e.g. Anderson and Biddle, 1975; Frase and Schwarz, 1975) has also been subject to a selective attention interpretation (Andre, 1979; Sagaria and Di Vesta, 1978).

A number of theorists have proposed hierarchical models of text structure (e.g. Crothers, 1972; Frederiksen, 1975; Kintsch and Van Dijk, 1975; Rumelhart, 1975; Thorndyke, 1977). Higher positions in these hierarchies have been generally occupied by more central or important propositions and generally these are better recalled, more accurately recognised and more rapidly verified. Reder and Anderson (1980) have concluded that in hierarchical representations of text, details can be retrieved only by first retrieving the higher level units. Further, evidence is presented by these authors which suggests that learning material from summaries is at least as good as reading from the original text. A "selective attention" interpretation is suggested to account for this insofar as learners may be unwilling or unable to isolate the main points in a text and merely skim details that are not of great interest.

The experiments of unit 1 investigate some aspects of learner and experimenter-generated organisational strategies and their effects on recall. The materials are of the type for which two alternative organisational "dimensions" can map easily onto the subject-matter. The materials are of the type originally suggested by Frase (1969) and the relevant research is introduced in experiment 1. This area of research appears to be valuable because it may lead to specific recommendations for improving textual materials so that they become more optimally structured for efficient instruction.

2.2 EXPERIMENT 1 : CLUSTERING AND SERIATION STRATEGIES IN FREE LEARNING AND FREE RECALL FROM CONCEPT NAME BY CONCEPT ATTRIBUTE MATRICES

Introduction

When learning randomly ordered word lists, subjects tend to adopt a clustering strategy during recall in which items are subjectively organised into experimenter-defined categories if they are highly dominant (Bousfield, 1953) or into idiosyncratic categories if they are not (Seibel, 1964). Frase (1969) investigated organisation strategies in free-recall following learning of passages comprised of simple sentences. Each sentence in the passage expressed an association between a concept name and a value of a concept attribute. The text was generated from a table describing eight characteristics of six chessmen. The names of the men and the names of the characteristics were conceived of as superordinates naming the rows and columns of the table. The cell entries in the table were the values of the characteristics (e.g. the pawn captures diagonally; the queen captures at it moves). Frase (1969) demonstrated that providing a reader with information about the superordinates would aid learning. Those subjects who were informed before reading that there were eight characteristics and what these characteristics were (the superordinate labels) recalled more of the text on later learning than uninformed subjects.

Schultz and Di Vesta (1972) extended the generality of earlier studies (Cofer et al, 1966; Frase, 1969) by examining clustering and recall from a passage that was more closely analogous to materials used in instructional settings. These investigators' primary aim was to examine the conditions under which the subjects' clustering in recall deviated from the organisation of the presented passage. In Frase's (1969) earlier experiment, subjects were given the opportunity to take notes while they studied the passage. Schultz and Di Vesta (1972) reasoned that note taking during the study period would have the effect of influencing the learner to change his clustering strategy from the implicit passage organisation to one of his own choosing. Thus, there would be more variation in clustering strategies among subjects who take notes than among those who learn without notes, since notes may provide a means of "external storage" and a device to rearrange the organisational structure of the passage in stereotypic fashion.

Further, these authors reasoned that when the learner relies on a passage organisation consistent with his dominant clustering strategy during learning, he would employ that organisational mode during recall with the effect of facilitating what is remembered. However, when the passage organisation is inconsistent with the learners dominant strategy, then the strategy normally employed must be relinquished and as a consequence a different less well-practised strategy must be employed to the detriment of recall.

The present experiment attempts to extend and clarify several issues apparent in earlier work (e.g. Frase, 1969; Schultz and Di Vesta, 1972). Firstly in the attempt to extend research findings derived from list-learning tasks to materials more analogous to conventional instructional text, the material necessarily becomes more internally structured and dependent on the relations between "items". Consequently, using more complex experimental materials is probably not just a question of degree of realism but may also invoke different organisational domains. With increasing complexity of experimental materials, learner's schematic activities may become increasingly important. Although most memory experiments have been designed to study either categorical or schematic organisation, J. M. Mandler (1979) has pointed out that we engage in both types of activities all the time. A great deal of categorical organisation occurs as an automatic part of perception although in a typical list-learning experiment the overall categorical organisation has to be uncovered through data-driven processing during the course of presentation. In contrast learners advance knowledge and expectations of common event sequences appear to operate as conceptually-driven processing by structuring and giving meaning to incoming information. Viewed from this perspective, the question of whether the structure of instructional materials can prescribe instructional sequences needs to be extended to consider learners' "subject-matter schemata". This could begin to clarify the primary methodological problem of finding instructional sequences which are both intelligible and yet do not violate the structure of the subject-matter. The structure of the instructional material used in the present experiment, although artificial, has the advantage of prescribing two "logical" sequences which are directly mapped onto the structure.

Specifically, if previous studies (e.g. Frase, 1969; Schultz and Di Vesta, 1972) have identified a stereotypic expectation of an event sequence (relating to the categorical blocking of sentences by concept name rather than concept attribute) then sequencing instructional material to match this schema should facilitate learning. Conversely mismatched instructional material should lead to performance decrements at recall. This line of reasoning can be subsumed under Pask's (1969, 1975) and Pask and Scott's (1971) more general contention that effective learning takes place only if the learner or instructor selected strategy is matched to the learner's existing competence in being able to execute strategies of a particular class. For the present experimental purposes, "competence" may be related to subject expectations of the organisation of the learning materials. If the learner or experimenter selected clustering strategy matches this expectation, then learning should be facilitated.

The second issue arising from earlier research on organisers is that these aids might affect the retrieval of information not its acquisition. Gagné and Wiegand (1970), for instance, found that a topic sentence improved factual recall when it was presented before a retention test. Mandler (1967) introduced a procedure in which subjects were asked to sort items into groups prior to recall. He found, within a restricted range, that recall varied as a function of the degree to which subjects grouped the items at input. A number of studies of input organisation have subsequently utilised this sort-recall procedure (e.g. Bjorklund et al, 1977; Corsale and Ornstein, 1977; Puff, Murphy and Ferrara, 1977). Data from these studies have generally indicated several inconsistencies between the use of an organisation at stimulus input and output. Generally the organisation present at input is not always reflected at output and vice versa. The relationships among input organisation, output organisation and performance at recall appear to be complex, and little is currently known about the factors that might lead subjects to co-ordinate their retrieval pattern with organisational strategies at acquisition.

The present experiment does not use a sort-recall procedure but investigates subjects acquisition and recall strategies separately by examining constraints in learner's acquisition and recall sequences. With the particular type of experimental materials used it is possible to use the same measure of clustering organisation at input and output. Constraint in subjects selected acquisition (free-learning) and selected recall (free-recall) sequences of items are considered to reflect subjects attempts to structure their input and output respectively.

Since both seriation and clustering can give rise to superior recall (eg G.Mandler, 1969a;Postman, 1972) measures of both are investigated in relation to recall. Seriation refers to the correspondence between acquisition and recall sequences of items, whereas the clustering measures are related to the degree of category organisation in acquisition and recall. These measures are discussed in more detail in the "scoring" section of the results. It is anticipated that these measures will reflect subjects' underlying organisational structure and processes.

Frederiksen (1969) has discussed the notion of strategies acting as mediators between an individual's abilities and performance on learning tasks. This transfer is suggested to be due to the restructuring of the learner's task by the strategy adopted. This conceptualisation greatly widens the range of abilities which might be considered as important determiners of an individual's performance in learning. An individual being high or low in a particular ability may influence his performance by increasing or decreasing the probability that he will select specific strategies, or by influencing through positive transfer his performance using these strategies. Hunt et al (1973) have reported that high verbal subjects had a greater tendency to organise recall on the basis of the serial order of item presentation. In the present experiment, this question of whether ability data can provide an estimate of a learner's competence in executing strategies is approached by including a measure of general intelligence and investigating the association between this measure with measures of seriation, clustering and recall.

The present study was designed to examine the relative popularity of clustering by concept name and concept attribute in acquisition and recall. Attention is also given to the relative effects on amount recalled of seriation and clustering.

Method

Subjects: Ten students from the Faculty of Social Sciences & Humanities, University of Aston in Birmingham were randomly selected to serve as experimental subjects.

Materials: The instructional materials used were derived from two 4 x 4 concept name by concept attributematrices constructed according to the procedure described by Frase (1969). These consisted of concept attribute values for four different colours of paint (concept name) and four different characteristics of paint (concept attributes) for each paint. One of the matrices is illustrated in Fig. 2.1.

	RED	YELLOW	BLUE	WHITE
Price	4	6	5	8
Durability	2	4	7	9
Gloss	3	8	6	4
Texture	6	5	5	8

Fig. 2.1 4 x 4 Concept name by concept attribute matrix

The possible values for all four attributes were randomly assigned values 1 to 9. Each value in a cell therefore represents a concept. The value in the top left-hand corner of the matrix refers to:

$$\underbrace{\text{RED PAINT}}_{\text{concept name}} \qquad \underbrace{\text{HAS A PRICE}}_{\text{concept attribute}} \qquad \underbrace{\text{OF FOUR}}_{\text{attribute value}}$$

Two different sets of material were generated. These were identical matrices apart from different concept attribute values, which were randomly assigned in both cases.

Procedure

Upon entering the experimental room, each subject was administered Set 1 of the Raven's Advanced Progressive Matrices (Raven, 1965). After completion of this general intelligence test, each subject then read the experimental instructions. The subject's task was to ask the experimenter questions in order to elicit information about the concept attribute values. Legitimate questions included the concept name and concept attribute in any order. For example, "what is the price of red paint?" or "what is blue paint's durability?", are legitimate questions. In answer to such questions, the experimenter replied with the concept attribute value. Subjects could ask as many or as few questions as they liked in any order but they could only ask questions for eight minutes, at the end of which each subject was required to recall items in any order. The learning time of eight minutes had been previously determined from a pilot study and had been found to give adequate variability in the recall scores.

Subjects order of acquisition and recall was recorded by the experimenter.

After completion of the first task subjects were allowed five minutes rest and were then instructed that they were to undertake the same experimental task, but this time there would be different attribute values. After eight minutes subjects were again asked to recall, in any order, as many items as possible. Subjects order of acquisition and recall was again recorded by the experimenter. A copy of the verbatim instructions is given in Appendix 6(a).

Scoring

The proliferation of clustering measures has led to several reviews and comparisons of these measures (e.g. Colle, 1972; Shuell, 1975;Murphy, 1979) but to no final resolution as to what is the best measure of clustering. Since this measurement problem is invoked in any study where measures of organisation and recall are utilised, a brief discussion of the clustering and seriation measures adopted in the present experiment is included. It is clear, however, that until an adequate process model of organisation and memory is available, the direct measurement of many of the hypothesised underlying processes is difficult.

Typically, the degree of clustering in subjects' recall is inferred from a measure based on the number of category repetitions, r, (the number of times two items from the same category appear together in the output list). Since r would be expected to increase with increasing levels of recall, a clustering measure can be constructed by dividing r by some value related to the number of items recalled, n.

In the present experiment, subjects free-learning and free-recall protocols were scored for the number of questions asked, the number of items correctly recalled and the total number of items recalled. Subjects could select their acquisition (input) and recall (output) sequencies of items by either concept name (N), concept attribute (A) or randomly (R). This is illustrated below:-

(a) Example of sequencing by concept name (N) at acquisition or recall.

1. Red paint has a price of 4
2. Red paint has a gloss of 3
3. Red paint has a durability of 2, etc.

(b) Example of sequencing by concept attribute (A) at acquisition or recall.

1. Red paint has a price of 4
2. Yellow paint has a price of 6
3. Blue paint has a price of 5, etc.

(c) Example of sequencing randomly (R) at acquisition or recall.

1. Blue paint has a price of 5
2. Red paint has a gloss of 3
3. White paint has a texture of 8, etc.

For an item at acquisition or recall to be included in the N, A or R categories, subjects free-learning and free-recall protocols were scored as shown in the hypothetical example below.

Sequence of items at acquisition or items at recall	Category allocation
1. Red paint has a price of 4	A
2. Yellow paint has a price of 6	A
3. Blue paint has a price of 5	A
4. White paint has a price of 8	A
5. Yellow paint has a gloss of 8	A
6. Blue paint has a gloss of 6	A
7. Red paint has a gloss of 3	A
8. White paint has a gloss of 4	A
9. Red paint has a gloss of 3	A
10. Yellow paint has a price of 6	R
11. Yellow paint has a gloss of 8	N
12. Yellow paint has a durability of 4	N
13. White paint has a texture of 8	R
14. Blue paint has a durability of 7	R

An item is allocated to an R category if both concept name and concept attribute change in moving from one item to the next, unless subjects had previously exhausted a complete category set. In the example above, item 5 is allocated to the A category whereas item 10 is allocated to the R category.

Two ratio measures of clustering were calculated (one for acquisition and one for recall) and since subjects could select their acquisition or recall sequences by concept name (N), concept attribute (A) or randomly (R), six percentage strategy scores were derived as shown.

percentage acquisition strategy was calculated from

$$\frac{\text{number of N, A or R questions asked}}{\text{total number of questions asked}} \times 100$$

For each subject, the sum of percentage N, percentage A, and percentage R acquisition strategies equals 100%.

Percentage recall strategy was calculated from

$$\frac{\text{number N, A or R items recalled}}{\text{total number of items recalled}} \times 100$$

Percentage recall strategy was calculated for all, not just correct items, and consequently as with percentage acquisition strategy, for each subject, the sum of percentage N, percentage A and percentage R recall strategies equals 100%. This was possible since subjects could correctly recall the concept name/concept attribute combination but with an incorrect associated attribute value.

Simple ratio measures have come under criticism (Dalrymple-Alford, 1970; Frankel and Cole, 1970) because they are in part dependent on the category composition of the items remembered. For example the LR measure (Bousfield, 1953) is defined as r/n where r = category repetitions and n = number recalled. This measure would give identical scores for acquisition or recall sequences of NNAARR and NNNANN. In both cases r = 3 and n = 6 and LR = 0.5.

It is apparent, however, that this problem is not encountered with the percentage acquisition and percentage recall measures used in the present experiment, since they are calculated for each category and reflect the proportion of a particular category organisation selected by subjects at acquisition and recall. A measure relating the degree of clustering selected by subjects at acquisition and recall was calculated for N, A and R categories for each subject using the formula below:

$$100 - |\text{percentage acquisition strategy} - \text{percentage recall strategy}|$$

This gave three scores for each subject which are referred to as N, A and R clustering correspondence. In the limiting case where the percentage acquisition strategy and the corresponding percentage recall strategy were both zero, the correspondence measure was also assigned a zero score.

In addition to the clustering of items at acquisition and recall, subjects utilisation of input sequence as a means of item structuring is of interest in the present experiment. A measure of seriation which reflects the correspondence between the acquisition (input) and recall (output) sequences of items was calculated for each subject. This measure was calculated by dividing the number of repetitions of pairs of items at input which occur in the same sequence at output by the total number of items sampled (questions asked) at input. Since any pair of items which occur in the same sequence at input and output can be categorised at N, A or R pairs, three seriation scores were calculated for each subject. These are referred to as N, A and R seriation scores.

<u>Results</u>

The results are organised into three sections. The first section examines subjects utilisation of clustering strategies in the acquisition and recall phases of tasks 1 and 2. Clustering correspondence and seriation usage in tasks 1 and 2 is also examined. In the second section, the association between clustering strategies, clustering correspondence, seriation and amount recalled is examined. In the third section the association between scores on Ravens Advanced Progressive Matrices and dependent variables is investigated.

(i) <u>Clustering and seriation in acquisition and recall</u>

In order to examine the relative popularity of the percentage acquisition and percentage recall strategies adopted by subjects in tasks 1 and 2, Table 2.1 below gives the means and standard deviations for percentage acquisition and recall strategies summed across all subjects.

		Percentage acquisition strategy			Percentage recall strategy		
		N	A	R	N	A	R
TASK 1	$\bar{X}$	29.46	63.31	7.04	37.75	47.72	14.52
	SD	33.47	33.38	8.09	40.34	42.07	17.91
TASK 2	$\bar{X}$	49.86	42.49	7.67	63.14	32.51	4.38
	SD	39.41	41.69	7.35	43.24	41.25	6.88

Table 2.1 Means and standard deviations for percentage acquisition and percentage recall strategies for all subjects

In order to compare levels of strategy utilisation by subjects, correlated 't' tests between N, A and R strategies were calculated within the acquisition and recall phases at task 1 and task 2. (Table 2.2 below)

	ACQUISITION	RECALL
TASK 1	N < A n.s. N > R n.s. A > R p<0.01	N < A n.s. N > R n.s. A > R n.s.
TASK 2	N > A n.s. N > R p<0.01 A > R n.s.	N > A n.s. N > R p<0.01 A > R n.s.

Table 2.2 Correlated 't' test comparisons for percentages N, A and R strategy utilisation by subjects within the acquisition and recall phases at task 1 and task 2

Although it can be seen from Table 2.1 that the concept attribute strategy was the most popular in both acquisition and recall phases for task 1, Table 2.2 shows that no statistically significant differences were found for task 1 between the concept attribute and concept name strategies within the acquisition phase or the concept attribute and concept name strategies within the recall phase. For task 2 the concept name strategy was the most popular, particularly in the recall phase, although no significant differences were found (Table 2.2) between the concept name and concept attribute strategies in the acquisition phase or the concept name and concept attribute strategies in the recall phase. In both acquisition and recall phases for task 2, the concept name strategy is utilised more frequently than the random strategy, and Table 2.2 shows that these are significant differences.

In order to examine differences in levels of, and association between percentage acquisition and percentage recall strategies within tasks 1 and 2, correlated 't' tests and Pearson product moment correlation coefficients were calculated. 't' values, 'r' values and associated probabilities are given in Table 2.3 below. The + and - signs associated with t values respectively refer to a larger or smaller mean at recall.

	TASK 1			TASK 2		
	N	A	R	N	A	R
t	+1.07	-1.06	+1.66	+1.25	-0.64	-0.97
p(df=8)	ns	ns	ns	ns	ns	ns
r	+0.21	+0.34	+0.70	+0.71	+0.67	-0.03
p(df=8)	ns	ns	<0.05	<0.05	<0.05	ns

Table 2.3 Correlated 't' values, correlations and associated probabilities for percentage acquisition and percentage recall strategies within task 1 and within task 2

It can be seen from Table 2.3 that within both task 1 and within task 2 there are no significant differences between levels of percentage N, A and R strategy utilisation at the acquisition and recall phases. For task 1, Table 2.3 shows that the correlations between percentage N and A strategies at acquisition and recall were positive but non-significant, whereas the correlation between percentage R strategy was positive and significant. For task 2, Table 2.3 shows that the correlations between percentage N and A strategies at acquisition and recall were both positive and significant, whereas the correlation between percentage R strategy was negative and non-significant. It appears that within task 1 subjects are more inclined to change their clustering strategies between acquisition and recall (for N and A) whereas within task 2, subjects are more likely to use the same clustering strategy at acquisition and recall.

In order to examine differences in levels of,and association between percentage acquisition and percentage recall strategies between tasks 1 and 2, correlated 't' tests and Pearson product-moment correlation coefficients were calculated. 't' values, 'r' values and associated probabilities are given in Table 2.4 below. The + and - signs associated with 't' values respectively refer to a larger or smaller mean at task 2.

	% ACQUISITION STRATEGIES			% RECALL STRATEGIES		
	N	A	R	N	A	R
t	+1.78	-1.61	+0.18	+2.18	-1.31	-1.97
p(df=8)	ns	ns	ns	ns	ns	ns
r	+0.56	+0.48	+0.10	+0.65	+0.65	+0.52
p(df=8)	ns	ns	ns	<0.05	<0.05	ns

Table 2.4 Correlated 't' values, correlations and associated probabilities for percentage acquisition and percentage recall strategies between task 1 and between task 2

It can be seen from Table 2.4 that there are no significant correlations between acquisition strategies between tasks 1 and 2. However, Table 2.4 shows that both N and A recall strategies are significantly positively correlated between task 1 and task 2. Table 2.4 shows that there are no significant differences between task 1 and task 2 for amount of N, A or R strategy utilisation for either the acquisition or recall phase.

It appears that subjects are more inclined to change their acquisition strategies rather than their recall strategies between tasks 1 and 2. However, subjects also change their within task strategies for both the acquisition and recall phases. Percentage change in acquisition strategies between task 1 and task 2 were compared with a correlated 't' test. No significant difference was found ($t = 0.14$, $df = 8$, ns). Similarly, percentage change in recall strategies between task 1 and task 2 were compared and no significant difference was found ($t = 0.96$, $df = 8$, ns).

The diagram below (Fig. 2.2) summarises subjects' tendency ($n = 10$) to change their relative utilisation of clustering strategies (N, A and R) between the sequence of experimental events.

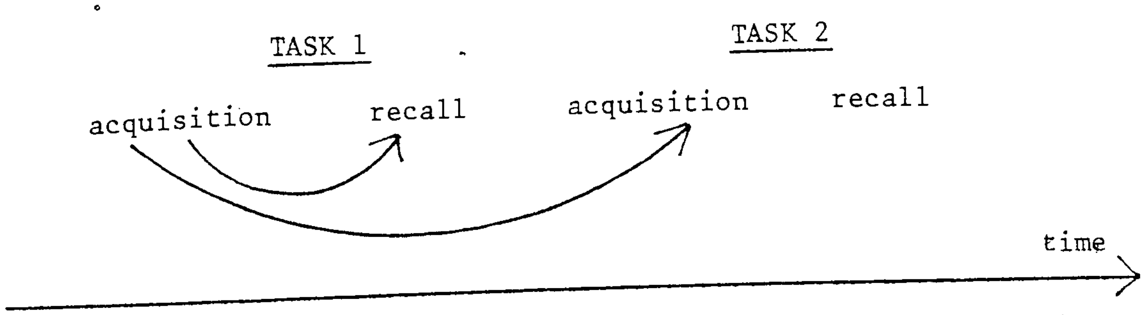


Fig. 2.2 Representation of subjects' tendency to change their relative utilisation of N, A and R clustering strategies between the sequence of experimental events

In order to examine differences in levels of and association between N, A and R clustering correspondence scores (see scoring section) between task 1 and task 2, correlated 't' tests and Pearson product moment correlation coefficients were calculated. 't' values, 'r' values and associated probabilities are given in Table 2.5 below. The + and - signs associated with t values respectively refer to a larger or smaller mean at task 2.

	Clustering correspondence scores		
	N	A	R
t	+2.49	+0.80	-0.50
p (df=8)	0.05	ns	ns
r	+0.72	+0.70	+0.72
p (df=8)	<0.05	<0.05	<0.05

Table 2.5 Correlated 't' values, correlations and associated probabilities for clustering correspondence scores between task 1 and task 2

It can be seen from Table 2.5 that there is a significant difference between the amount of N clustering correspondence between tasks 1 and 2 (in the direction of more N clustering correspondence at task 2). It can be seen from Table 2.5 that there are no significant differences between the amount of A and R clustering correspondence between task 1 and task 2. Table 2.5 shows that for N, A and R clustering correspondence scores there are significant positive correlations between task 1 and task 2. These significant correlations suggest that subjects maintain their relative utilisation of N, A and R clustering correspondence scores at task 2, although at task 2 subjects increase their N clustering correspondence. This elevation does not occur for A or R clustering correspondence scores at task 2.

In order to examine differences in levels of and association between N, A and R seriation scores (see scoring section) between task 1 and task 2, correlated 't' tests and Pearson product moment correlation coefficients were calculated. 't' values, 'r' values and associated probabilities are given in Table 2.6 below. The + and - signs associated with t values respectivelyrefer to a larger or smaller mean at task 2.

	Seriation score		
	N	A	R
t	+2.05	-0.94	-1.90
p (df=8)	ns	ns	ns
r	+0.44	+0.13	-0.02
p (df=8)	ns	ns	ns

Table 2.6 Correlated 't' values, correlations and associated probabilities for seriation scores between task 1 and task 2

It can be seen from Table 2.6 that there are no significant differences between the amount of N, A or R seriation between task 1 and task 2. Table 2.6 also shows that for N, A and R seriation scores, there are no significant correlations between task 1 and task 2.

(ii) Clustering strategies, clustering correspondence, seriation and amount recalled.

The percentage acquisition and percentage recall strategies for N, A and R categories were correlated with recall scores for task 1 and task 2. 'r' values and associated probabilities are given in Table 2.7 below.

		% ACQUISITION STRATEGIES			% RECALL STRATEGIES		
		N	A	R	N	A	R
TASK 1	r	+0.19	-0.25	+0.25	+0.39	-0.44	+0.35
	p	ns	ns	ns	ns	ns	ns
TASK 2	r	+0.46	-0.51	+0.35	+0.08	+0.06	+0.19
	p	ns	ns	ns	ns	ns	ns

Table 2.7 Correlations between percentage acquisition strategies and percentage recall strategies with recall scores for task 1 and task 2

It can be seen from Table 2.7 that there are no significant correlations between N, A or R percentage acquisition strategies and recall scores on either task 1 or task 2. Similarly Table 2.7 shows that there are no significant correlations between N, A or R percentage recall strategies and recall scores on either task 1 or task 2.

Recall at task 2 was found to be significantly better than recall at task 1 ($t = 4.59$, $df = 8$, $p<0.01$).

N, A and R clustering correspondence scores were correlated with recall scores for task 1 and task 2. 'r' values and associated probabilities are given in Table 2.8 below.

		Clustering correspondence scores		
		N	A	R
TASK 1	r	+0.13	+0.34	+0.20
	p	ns	ns	ns
TASK 2	r	+0.76	+0.46	+0.35
	p	<0.05	ns	ns

Table 2.8 Correlations between N, A and R clustering correspondence scores and recall scores for task 1 and task 2

It can be seen from Table 2.8 that the only significant correlation between clustering correspondence scores and recall scores occurs for N clustering correspondence score and recall score on task 2. More N clustering correspondence is utilised at task 2 than at task 1 (Table 2.5) and this tends to be due to subjects changing their acquisition rather than their recall strategies (Table 2.4).

N, A and R seriation scores were correlated with recall scores for task 1 and task 2. 'r' values and associated probabilities are given in Table 2.9.

		Seriation score		
		N	A	R
TASK 1	r	+0.48	-0.06	-0.04
	p	ns	ns	ns
TASK 2	r	+0.68	+0.23	+0.20
	p	<0.05	ns	ns

Table 2.9 Correlations between N, A and R seriation scores and recall scores for task 1 and task 2

From Table 2.9 it can be seen that the only significant correlation between seriation scores and recall scores occurs for N seriation score and recall scores on task 2. Although more N seriation is utilised at task 2 (Table 2.6) this is not significantly different from N seriation utilisation by subjects on task 1.

It is apparent that both N clustering correspondence scores (Table 2.8) and N seriation scores (Table 2.9) are both significantly positively correlated with recall score at task 2. All or part of the correlation between N clustering correspondence scores and recall scores at task 2 may result because both are correlated with N seriation scores. The effects of N seriation scores were eliminated from the correlation between N clustering correspondence scores and recall scores by calculating a partial correlation coefficient. The partial correlation coefficient between N clustering correspondence scores and recall score when the effects of N seriation scores have been eliminated is +0.69

($t = 2.52$, $df = 7$, $p<0.05$).

Similarly, all or part of the correlation between N seriation scores and recall scores at task 2 may result because both are correlated with N clustering correspondence scores. The effects of the N clustering correspondence scores were eliminated from the correlation between N seriation scores and recall scores by calculating a partial correlation coefficient. The partial correlation coefficient between N seriation scores and recall scores when the effect of N clustering correspondence scores have been elimindes is +0.58 ($t = 1.88$, $df = 7$, n.s.).

It is apparent that the correlation between N clustering correspondence scores and recall scores is still significant when the effects of N seriation scores are eliminated, whereas the correlation between N seriation scores and recall scores is no longer significant when the effects of N clustering correspondence scores are eliminated.

(iii) Raven's Advanced Progressive Matrices (Set 1) and performance

Scores on Set 1 of Raven's Advanced Progressive Matrices were correlated with recall scores at task 1 and task 2. These were found to be $r = -0.32$, $df = 8$, n.s. for task 1 and $r = 0.17$, $df = 8$, ns. for task 2.

Scores on Set 1 of Raven's Advanced Progressive Matrices were correlated with N, A and R percentage acquisition strategies, N, A and R percentage recall strategies, N, A and R clustering correspondences scores and N, A and R seriation scores for tasks 1 and 2. These correlations are given in Table 2.10.

		N	A	R
Percentage Acquisition Strategies	task 1	-0.76*	+0.70*	+0.27
	task 2	-0.19	+0.15	+0.19
Percentage Recall Strategies	task 1	-0.15	+0.14	+0.10
	task 2	-0.05	+0.11	-0.36
Clustering Correspondence scores	task 1	+0.28	-0.10	-0.30
	task 2	-0.27	-0.01	-0.32
Seriation scores	task 1	-0.50	+0.35	+0.16
	task 2	+0.28	-0.65*	+0.20

df = 8, $*p<0.05$

Table 2.10 Correlations between Set 1 RAPM and performance measures

It can be seen from Table 2.10 that N percentage acquisition strategy at task 1 is significantly negatively correlated with recall score. Table 2.10 also shows that A percentage acquisition strategy at task 1 is significantly correlated with recall score. It appears that more intelligent subjects are more likely to adopt an A percentage acquisition strategy at task 1 although at task 2 this is not the case. Less intelligent subjects are more likely to adopt an N percentage acquisition strategy at task 1 although again this is not the case at task 2. A tentative explanation is offered for these findings in the discussion and conclusions of this experiment.

It can be seen from Table 2.10 that no significant correlations were found between scores on Set 1 of Raven's Advanced Progressive Matrices and N, A or R clustering correspondence scores.

Table 2.10 shows that scores on Set 1 of Raven's Advanced Progressive Matrices and A seriation scores at task 2 are significantly negatively correlated. It appears that more intelligent subjects are less likely to be associated with high A seriation scores at task 2. No explanation is immediately apparent for this result, but with a five percent significance level, the possibility of a type 1 error cannot be discounted.

Discussion and Conclusions

An examination of the results reveal several interesting findings. No significant differences were found between subjects' utilisation of clustering by concept name or concept attribute at either the acquisition or recall phases in task 1 or task 2, although the random clustering strategy was significantly less popular in some conditions (see Table 2.2). The previous findings (Schultz and Di Vesta, 1972) relating to the dominance of clustering by concept name in recall have not been supported by the present experiment, although concept name recall strategies were certainly more widely used (but not significantly more) at task 2.

Subjects in the present investigation are inclined to change their acquisition and recall strategies both within and between tasks. Within task 1, there are no significant correlations between the name or attribute strategies at acquisition and recall, demonstrating that subjects are inclined to change their relative utilisation of clustering by concept name or concept attribute between the two learning phases. Within task 2, significant positive correlations are detected between the name and the attribute strategies at acquisition and recall, demonstrating that subjects are not inclined to change their relative utilisation of clustering by concept name or concept attribute between the two learning phases. Random sequencing (R percentage clustering strategy) is significantly positively correlated between the acquisition and recall phases at task 1 and not at task 2 (see Table 2.3).

Between task 1 and task 2, subjects percentage N, A or R acquisition strategies are not significantly correlated, demonstrating that subjects are inclined to change their acquisiton strategies between task 1 and task 2. Subjects percentage N and A recall strategies are significantly positively correlated between task 1 and task 2, which suggests that subjects are more inclined to change their acquisition strategies rather than their recall strategies at their second encounter with the task (see Table 2.4). It is clear that previous assumptions (Schultz and Di Vesta, 1972) that recall strategies will manifest themselves at the acquisition phase of learning do not seem to be always justified. It is clear from the present findings that this only appears to be the case when subjects have had practice at the task. This cannot be due to subjects being unaware of the organisational aids of concept name and concept attribute categories at task 1, since this was an essential part of being able even to perform the task. Generally, within the present experiment, subjects are more willing, and perhaps more able to change their acquisition clustering rather than their recall clustering.

The outcome of subjects changing their acquisition strategies at task 2 is a significant increase in concept name clustering correspondence score compared to task 1. At task 2 concept attribute and random clustering correspondence scores are not significantly different compared to task 1. It can be seen from Table 2.6 that subjects did not significantly increase their N, A or R seriation scores at task 2. Rather at task 2 subjects tend to change their acquisition strategies to effect an increase in their name clustering correspondence scores. This clustering correspondence might be viewed as a more appropriate strategy since it is associated with improved recall. This selection and organisation of the instructional material at input might be considered to reflect an underlying expectation concerning the organisation of the subject-matter, which becomes evident with familiarity with the task. This expectation stems from the observation that concept name rather than concept attribute clustering is more frequently employed in most instructional material. Possibly, at task 2 subjects bring their prior knowledge, in the form of a simple event schema, rather than the structures that underly intelligence to bear on their strategic manipulations of the instructional materials.

2.3 EXPERIMENT 2 : MATCHING AND MISMATCHING OF EXPERIMENTER-IMPOSED ACQUISITION AND RECALL STRATEGIES ON THE LEARNING OF CONCEPT NAME BY CONCEPT ATTRIBUTE MATRICES

Introduction

The results of Experiment 1 have shown that when subjects are familiar with the task (i.e. at task 2) and organise their acquisition and recall clustering in a manner in which there is a high degree of correspondence between the amount of clustering by concept name between the acquisition and recall phases of learning, then recall is improved. This result is consistent with the view expressed by Ornstein and Corsale (1979) who suggest that output organisation might be maximally effective when it reflects an organised search of the structures established at input. The view received earlier support from an experiment performed by Corsale (1978) who utilised a sort-recall procedure for all subjects and then instructed some subjects to recall according to the groupings they initially formed. The results indicated clear effects of constraining such that under conditions where subjects were instructed to recall according to the input groupings, recall was facilitated. From the instructional viewpoint, the possibility arises that by constraining learners acquisition and recall sequences in accord with external categories that map easily onto verbal instructional materials then recall may be enhanced. In order to investigate the relationship between input/output correspondence and recall further, the present experiment investigates learners' performance under conditions where the correspondence between input and output sequences is experimenter rather than learner-controlled.

The use of organisational strategies in structuring items at input and output appears to stem in part from subjects' knowledge of the organisational structures implicit in the instructional material. This raises the issue of the role of subjects prior knowledge in tasks of this type. It has been suggested previously that with the particular type of instructional material being considered, that this prior knowledge might be usefully conceived of as a simple event schema relating to subjects expectations of concept name and concept attribute events. Consequently, in the present experiment, it is suggested that imposed matching by concept name sequence at acquisition and recall may lead to enhanced recall compared to all other conditions. Matching by concept attribute sequence at acquisition and recall is hypothesised to result in superior recall performance compared to mismatched or random acquisition or recall sequences.

Method

Subjects and design: Sixty students from the Faculty of Social Sciences & Humanities, University of Aston in Birmingham were randomly selected and allocated to six experimental conditions to give equal numbers of ten subjects in each condition.

	Acquisition	Recall	
Condition 1	Concept Name	Concept Name	N/N Matched
Condition 2	Concept Name	Concept Attribute	N/A Mismatched
Condition 3	Concept Attribute	Concept Attribute	A/A Matched
Condition 4	Concept Attribute	Concept Name	A/N Mismatched
Condition 5	Randomly	Randomly	R/R Matched
Condition 6	Randomly	Randomly	R/R Mismatched

In condition 5 the same random sequence is imposed at acquisition and recall, whereas in condition 6, a different random sequence is imposed at acquisition and recall.

Materials: The same two 4 x 4 concept name by concept attribute matrices were used as in Experiment 1. Each statement linking concept name, concept attribute and attribute value was printed on a separate card. This gave two packs of 16 cards each. Two identical packs (without the attribute values) were produced for the purposes of recall.

Procedure

Each of the sixteen statements was printed on one side of a card. The Subject's task was to learn the statements by progressing through the cards one by one by picking the top card off the pack. After subjects have finished with each card they were instructed to place it print side downwards to one side of the original pack, forming a separate pile. Subjects had 5 minutes (time determined by a pilot study) to learn the statements and within the time, could work at their own pace. Subjects could work through the pack any number of times, but could not go back to a card once it was placed in the separate pile. This was to preserve the acquisition strategy sequence. When working through the cards on a second or subsequent occasion, subjects were instructed to simply turn over the pile of cards and start again. The experimenter informed subjects when the time was up.

At the end of 5 minutes, subjects were asked to recall the values of the attribute values in a particular order. To do this, subjects were given another pack of cards identical to the pack they had been learning from, but without the attribute values. Subjects were asked to read the top card of the recall pack, write the value on the piece of paper provided, and place the card face side downwards to one side of the pack. Subjects did the same with the next card and so on. Subjects had as long as they liked to do this but only had one opportunity to recall each statement. In other words, to preserve the recall strategy sequence, subjects were not allowed to go back to correct any answers.

After completion of this task (task 1) subjects were instructed that they were to undertake the same experiment but this time (task 2) there would be different concept attribute values. A copy of the verbatim instructions is given in Appendix 6(b).

Scoring

Three measures of subjects' performance were taken for task 1 and task 2.

(i) Number of cards inspected

(ii) Total recall time for all items

(iii) Recall score (i.e. number correctly recalled)

Results

One way analyses of variance (CR6 - Kirk, 1968) and subsequent Tukey's multiple comparison of means (where appropriate) were calculated for the three dependent variables under the six treatments in task 1 and task 2. The analysis of variance summary tables are given in Appendix 1 (Tables a, b, c, d, e, and f). A summary of the results is given in Table 2.11. In this table R/R_5 refers to the matched random treatment and R/R_6 refers to the mismatched random treatment.

It can be seen from Table 2.11 that there were no significant differences betwen the six experimental conditions for number of cards inspected at the acquisition phase for task 1 ($F = 1.55$, $df = 5,54$, ns) or for task 2 ($F = 1.10$, $df = 5,54$, ns).

For the dependent variable of recall time, Table 2.11 shows that for task 1 there is a significant difference between the six experimental conditions ($F = 4.74$, $df = 5,54$, $p<0.01$). A subsequent Tukey's multiple comparison of means revealed that the differences were located as follows. Items in the mismatched condition N/A took significantly longer to recall than items in the matched N/N condition ($p<0.05$). Items in the mismatched condition N/A took significantly longer to recall than items in the matched random condition R/R_5 ($p<0.01$), and significantly longer than items in the mismatched random condition R/R_6 ($p<0.05$). For recall time at task 2 there was also a significant difference between the six experimental conditions ($F = 4.31$, $df = 5,54$, $p<0.01$). A subsequent Tukey's multiple comparison of means revealed that the differences were located as follows. Items in the mismatched condition N/A took significantly longer to recall than items in the matched condition N/N ($p<0.01$). Items in the mismatched condition A/N took significantly longer to recall than items in the matched condition N/N ($p<0.01$).

For the dependent variable of recall score Table 2.11 shows that for task 1 there is a significant difference between the six experimental conditions ($F = 4.83$, $df = 5,54$, $p<0.01$). A subsequent Tukey's multiple comparison of means revealed that the differences were located as follows. Subjects in the matched condition N/N correctly recalled more items than subjects in the matched random condition R/R_5 ($p<0.01$) and more items than subjects in the mismatched random condition R/R_6 ($p<0.01$). Subjects in the matched condition A/A correctly recalled more items than subjects in the matched random condition R/R_5 ($p<0.01$) and more items than subjects in the mismatched random condition R/R_6 ($p<0.01$). There were no significant difference in recall score

DEPENDENT VARIABLES		F (df=5,54)	P	TUKEY'S MCOM SIGNIFICANT CONTRASTS	P
Number of cards inspected	Task 1	1.55	n.s.		
	Task 2	1.10	n.s.		
Recall time	Task 1	4.74	<0.01	N/A > N/N	<0.05
				N/A > R/R_5	<0.01
				N/A > R/R_6	<0.05
				A/N > R/R_5	<0.05
	Task 2	4.31	<0.01	N/A > N/N	<0.01
				A/N > N/N	<0.01
Recall score	Task 1	4.83	<0.01	N/N > R/R_5	<0.01
				N/N > R/R_6	<0.01
				A/A > R/R_5	<0.01
				A/A > R/R_6	<0.01
	Task 2	3.77	<0.01	A/A > A/N	<0.05
				A/A > R/R_5	<0.05
				A/A > R/R_6	<0.05

Table 2.11 F values and Significant Contrasts for the 3 dependent variables in task 1 and task 2

between the matched condition N/N and the matched condition A/A. For recall score at task 2, Table 2.11 shows that there is a significant difference between the six experimental conditons ($F = 3.77$, $df = 5,54$,

$p<0.01$). A subsequent Tukey's multiple comparison of means revealed that the differences were located as follows. Subjects in the matched condition A/A correctly recalled more items than subjects in the mismatched condition A/N ($p<0.05$) and more items than subjects in the matched random R/R_5 ($p<0.05$) and mismatched random R/R_6 ($p<0.05$) conditions. There was no significant difference in recall score between the matched condition N/N and the matched condition A/A.

It is apparent that in task 1 both matched name (N/N) and matched attribute (A/A) treatments resulted in superior recall scores compared to both random treatments (matched and mismatched). No significant difference in recall score was found between N/N and A/A conditions within task 1. Matching acquisition and recall sequences by concept name or concept attribute clearly enhances recall. The mismatched treatments (N/A and A/N) resulted in significantly no better recall scores than those achieved by subjects in both random treatments.

In task 2, although the matched name treatment (N/N)approached significance compared to the random treatments for recall score, only the matched attribute treatment (A/A) resulted in significantly superior recall scores compared to one mismatched condition (A/N) and both random treatements. For recall score, it appears that the beneficial effects of providing matched acquisition are recall sequences by concept name (N/N) apparent at task 1 are not apparent at task 2. However, for recall time treatment N/N resulted in significantly faster recall than treatment N/A at both tasks 1 and 2. Within task 2 treatment N/N was the fastest recall condition (significantly faster than either N/A or A/N mismatched treatments).

In order to examine the relationships among the three dependent variables, Pearson product moment correlation coefficients were calculated for the 3 dependent variables at each condition at tasks 1 and 2. These 'r' values are given in Table g of Appendix 1. It can be seen from Table g of Appendix 1 that of the 36 correlation coefficients calculated, only one is significant at $p<0.01$ (α set at this level to minimise type 1 errors). Recall time and recall score is significantly negatively correlated within the matched condition N/N at task 2 ($r = -0.88$, df = 8, $p<0.01$). It appears that within this condition subjects who recall the set of items faster recall more. However, although at task 2, recall time is particularly short for the N/N condition, recall score is not significantly better than at any other experimental treatment. These results possibly suggest that within the N/N condition subjects need to restructure the input structure less to meet the required output sequence. However, at task 2 this does not enhance the number of items correctly recalled.

In order to investigate differences in subjects' performance at task 1 and task 2, correlated 't' tests were calculated between task 1 and 2 under the six treatments for the three dependent variables. The results are given in Table 2.12. The + and - signs prefixing the t values respectively refer to a larger or smaller mean at task 2.

It can be seen from Table 2.12 that in all treatment conditions, the number of cards inspected is greater at task 2 than at task 1. Table 2.12 shows that significantly greater increases in number of cards inspected at task 2 occur for the matched condition N/N ($t = 2.74$, df = 8, $p<0.05$), the matched condition A/A ($t = 2.93$, df = 8, $p<0.05$), the mismatched condition A/N ($t = 3.57$, df = 8, $p<0.01$) and

INDEPENDENT VARIABLES		CONDITION 1 N/N	2 N/A	3 A/A	4 A/N	5 R/R_5	6 R/R_6
Number of cards Inspected	t	+2.74	+1.70	+2.93	+3.57	+2.65	+1.86
	p	<0.05	n.s.	<0.05	<0.01	<0.05	n.s.
Recall Time	t	-3.76	-1.65	-1.80	-1.07	+0.07	-0.20
	p	<0.01	n.s.	n.s.	n.s.	n.s.	n.s.
Recall Score	t	+0.84	+2.04	+2.62	-0.09	+1.28	+1.18
	p	n.s.	n.s.	<0.05	n.s.	n.s.	n.s.

Table 2.12 Correlated 't' values and associated probabilities between tasks 1 and 2 for three measures of performance under the six experimental treatments

the matched random condition R/R_5 ($t = 2.65$, $df = 8$, $p<0.05$). This increase in number of cards inspected at task 2 might reflect subjects taking a more active role in acquisition as they become more familiar with the structure of the input material. Subjects appeared to be sequentially searching for the next item in their preferred sequence rather than acquiring items solely on the basis of the experimenter-prescribed sequence.

It can be seen from Table 2.12 that there are no significant differences in recall time between task 1 and task 2 for conditions N/A A/A, A/N, R/R_5 and R/R_6. For condition N/N recall time is significantly faster at task 2 than at task 1 ($t = 3.76$, $df = 8$, $p<0.01$).

Differences in recall score between task 1 and task 2 are not significant for conditions N/N, N/A, A/N, R/R_5 and R/R_6 (see Table 2.12). Only in condition A/A do subjects significantly improve their recall with practice ($t = 2.62$, $df = 8$, $p < 0.05$).

Discussion and conclusions

The experiment has demonstrated that matching the sequence in which learners must deal with items at acquisition and recall can enhance recall under some conditions. This correspondence between input and output sequences is only effective when the matched sequence of items reflects either of the two alternative categorical organisations which can be imposed on the instructional material. This follows from the findings (see Table 2.11) that the matched A/A and N/N treatments both resulted in superior recall score compared to the matched random treatment R/R_5 at task 1 and the matched A/A treatment resulted in superior recall score compared to the matched random treatment R/R_5 at task 2. The sequence of items at acquisition and recall was also matched in the R/R_5 condition but in this condition item sequence did not reflect either alternative categorical organisation.

The finding that the R/R_5 treatment did not result in improved recall compared to the mismatched random condition R/R_6 (see Table 2.10) suggests that subjects in the present experiment do not take advantage of seriation correspondence in the input and output sequences. As in Experiment 1, it appears that clustering rather than seriation correspondence enhances recall.

The low levels of recall following both random treatments (R/R_5 and R/R_6) suggests that subjects are unable to discover the implicit categorical input structure when items are randomly presented. There is, however, a significant increase in the number of cards inspected at task 2 for subjects in the matched random condition R/R_5 (see Table 2.3) which is not apparent for subjects in the mismatched random condition R/R_6. Possibly subjects in R/R_5 are beginning to attempt to more actively structure the input sequence by sequentially searching for the next item in their preferred sequence rather than relying on the imposed input sequence. If subjects were adopting this strategy, it was not reflected in improved recall for the R/R_5 compared to the R/R_6 condition (see Table 2.2).

The results generally support the hypothesis that matching by concept name or by concept attribute at acquisition and recall can enhance recall. The mismatched treatments (N/A and A/N) resulted in significantly no better recall scores than the random treatments at both task 1 and task 2 (see Table 2.11). However, the suggestion that matching by concept name will result in the highest recall scores of all conditions has not been substantiated. There are no significant differences in recall scores for subjects in the matched N/N treatments compared to the matched A/A treatments at task 1 or task 2. Since subjects clearly benefit from the instructional sequence being organised along the same categorical dimension at input and output then they must be bringing their prior knowledge of the implicit organisational structure to bear on the instructional materials. The suggestion that this prior knowledge can be usefully described as a simple event schema in which expectations of concept name organisation has been incorporated by subjects is not supported by the lack of significant difference between recall scores under treatments N/N and A/A. However there are two clear performance differences between the N/N and A/A treatments. Firstly, recall time is significantly faster for items in the N/N condition at task 2 whereas this is not the case for items in the A/A condition at task 2 (see Table 2.12). Further, there is a significant negative correlation (see Table g, Appendix 1) between recall time and recall score for items at task 2, whereas this is not the case for items in the A/A condition at task 2. These results might suggest that when subjects are familiar with the task organisation by concept name at input and output this reflects some aspect of subjects underlying knowledge structure.

2.4 EXPERIMENT 3 : MATCHING AND MISMATCHING OF EXPERIMENTER-IMPOSED ACQUISITION AND RECALL STRATEGIES ON THE LEARNING OF TEXTUAL MATERIALS

Introduction

The present experiment attempts to extend the findings of the previous experiments (Experiments 1 and 2) by examining organisation and recall performance in materials which are presented as passages, rather than as discrete items. In this way, the instructional passages are more analogous to the materials used when learning takes place from a text. Sentences in the passages were experimentally arranged in three ways; grouped by concept name, grouped by concept attribute or randomly ordered. Similarly, order of recall can be experimentally arranged so that recall sequence is by concept name, concept attribute or randomly. As in Experiment 2, the present experiment maximises the degree of matching and mismatching of organisation at input and output. In contrast to Experiments 1 and 2, the sentences used in this experiment contained parenthetical phrases, and the order of the concept name and concept attribute element within the sentences was varied. It was expected, as Schultz and Di Vesta (1972) had found that these structural changes would not alter the effects of the passages on subjects categorical organisation. In addition, there is a further more important distinction between the textual material used in the present experiment and the simpler materials used in Experiments 1 and 2. Schultz and Di Vesta (1972) have reasoned that with textual materials, organisation by concept name means that the concept name elements of each sentence remain the same from one sentence to the next within a given paragraph and only the value of the concept attribute changes from sentence to sentence. In contrast, organisation by concept attribute means that both the concept name and concept attribute values change from sentence to sentence within a given paragraph. Consequently Schultz and Di Vesta (1972) have argued that organisation by concept name may have been favoured by their subjects because it requires the least amount of change from sentence to sentence and permits a relatively direct classification of information. If subjects adopt a clustering by concept name strategy then their task possibly becomes comparable to learning a number of serial-learning lists, each of which consists of a set of concept attribute values associated with a particular concept name. In a passage externally organised by concept attribute, both the concept name and concept attribute elements differ from sentence to sentence. A passage organised by concept attribute might therefore resemble a paired-associate task in which the same set of stimulus terms is paired with different response terms, in each paragraph. From this perspective, the subjects task in the previous experiments (Experiments 1 and 2) might be comparable to paired associate learning of four lists of four items for both the name and attribute, learner or experimenter-generated acquisition sequences. This follows since both the concept name/concept attribute combinations and the concept attribute values always change from item to item. This explanation is consistent with the finding of no significant differences in recall scores between those experimental conditions in Experiment 2 which are organised by concept name at acquisition (i.e. conditions N/N and N/A) and those organised by concept attribute at acquisition (i.e. conditions A/A and A/N). However, it has also been demonstrated (Experiment 2) that there are clear performance differences both within (between tasks 1 and 2) and between conditions N/N, N/A, A/A and A/N. These differences suggest that other factors apart from the input structure are operating. The principal factor appears to be the clustering correspondence between items at acquisition and recall. Consequently, in the present experiment both passage organisation and the clustering correspondence between acquisition and recall are expected to affect performance at recall. If passage organisation by concept name structures the task in a manner which requires fewer associations for learning than passage organisation by concept attribute, and high clustering correspondence between acquisition and recall is associated with improved recall then several specific predictions can be hypothesised.

Firstly, imposing acquisition by concept name should result in improved recall in those conditions where this occurs. This should particularly be the case where acquisition and recall are matched by concept name (condition N/N). In the mismatched conditions N/A and A/N it is hypothesised that condition N/A should be superior on recall score than condition A/N. For the matched attribute condition A/A, it is hypothesised that recall score will be superior to condition A/N and inferior to condition N/N. No prediction is made concerning the direction of difference of recall scores between conditions A/A and N/A.

Method

Subjects and design: Sixty students from the Faculty of Social Sciences & Humanities, University of Aston in Birmingham were randomly selected and allocated to six experimental conditions to give equal numbers of ten subjects in each condition. Each experimental condition is characterised by the combination of the organisation of the sentences within paragraphs at acquisition and the organisation of the questions at recall.

	Acquisition	Recall	
Condition 1	Concept Name	Concept Name	N/N Matched
Condition 2	Concept Name	Concept Attribute	N/A Mismatched
Condition 3	Concept Attribute	Concept Attribute	A/A Matched
Condition 4	Concept Attribute	Concept Name	A/N Mismatched
Condition 5	Randomly	Randomly	R/R_5 Matched
Condition 6	Randomly	Randomly	R/R_6 Mismatched

The sequence of items at acquisition and recall for the matched conditions 1 and 3 was identical. Condition 5 contrasts with condition 6 in that the former is matched (i.e. the same random sequence of items are used in acquisition and recall) whereas in the latter a different random sequence is imposed at acquisition and recall.

Materials: The basic experimental passages were constructed according to procedures described by Frase (1969). The constructed passages consisted of sentences describing five imaginary people. Five characteristics were described for each person (e.g. occupation, interests, marital status, etc.). This resulted in a matrix of five people (concept name) by five characteristics (concept attributes) shown in Fig. 2.3.

Statements were constructed for each cell in the 5 x 5 matrix. For example, the following sentences were based on the row of attributes describing occupation.

"Recently, John has been employed as a toolsetter in a car factory."

"A large hotel employs George as head chef."

CONCEPT ATTRIBUTE	CONCEPT NAME				
	JOHN	JIM	GEORGE	PETER	ANDREW
OCCUPATION	Tool-setter	Builder	Chef	Clerk	Student
MARITAL STATUS	Married	Divorced	Married	Single	Engaged
INTERESTS	Rugby	Music	Fishing	Reading	Historical buildings
DISPOSITION	Shy/ reserved	Outgoing/ Extravert	Placid/ easy-going	Anxious/ worried	Tense/ highly-strung

Fig 2.3 5 x 5 Concept name by concept attribute matrix used in the construction of the passage

"Peter works in a small business company, as an accounts clerk."

etc.

Three different sets of materials were developed. One was based on the organisation of statements according to concept name, that is, the statements were derived from the contents of the columns of the matrix. A second was organised by concept attribute, that is, the statements were derived from the contents of the rows of the matrix. A third consisted of arranging the sentences in random order. Each of the three versions of the passage was arranged into five paragraphs; each paragraph consisted of five sentences.

For the purposes of constraining recall, a pack of cards with a question printed on each was produced. There were 25 cards in all; each question linking concept name and concept attribute. The cards could be arranged in a concept name, concept attribute, or random (matched or mismatched) sequence.

Procedure

Upon entering the experimental room each subject was seated at a desk. The subjects were told that they were about to participate in a learning experiment in which they were to study a passage containing descriptions of a number of imaginary people. Their task was to remember as many of the statements from the passage as possible. They were further told that they would have a 5 minute study period (time determined by a pilot study) and after being informed by the experimenter when the time was up, they were required to recall what they had learnt by answering questions. To do this, subjects were given the pack of recall cards and asked to read the top card of the recall pack, write their answer on the piece of paper provided and place the card face side downwards to one side of the pack. Subjects did the same with the question on the next card and so on. Subjects had as long as they liked to do this, but only had one opportunity to recall each statement. In other words, to preserve the recall strategy sequences, subjects were not allowed to go back to correct any answers. A copy of the verbatim instructions is given in Appendix 6(c).

Scoring

Two measures of subjects' performance were taken:

(i) Total recall time for all items

(ii) Recall score (i.e. number correctly recalled).

Results

One-way analyses of variance (CR6 - Kirk, 1968) and subsequent Tukey's multiple comparison of means were calculated for the two dependent variables under the six experimental treatments. These results are given in Table 2.13. In this table R/R_5 refers to the matched random treatment and R/R_6 refers to the mismatched random treatment.

The summary analysis of variance tables (Tables a and b) are given in Appendix 2.

It can be seen from Table 2.13 that for recall time there was a significant difference between the six experimental conditions ($F = 9.28$, $df = 5.54$, $p<0.001$). A subsequent Tukey's multiple comparison of means revealed that the differences were located as follows. Items in the matched condition A/A took significantly longer to recall than items in the matched random condition R/R_5 ($p<0.05$). Items in the mismatched conditions N/A and A/N both took significantly longer to recall than items in the matched random condition R/R_5 ($p<0.01$ and $p<0.05$ respectively). Items in the mismatched random condition R/R_6 took significantly longer to recall than items in the matched random condition R/R_5 ($p<0.01$). It is apparent that items in the matched random condition R/R_5 were recalled significantly faster than items in all other conditions except for the matched condition N/N.

Table 2.13 shows for recall score that there was a significant difference between the six experimental conditions ($F = 13.79$, $df = 5.54$, $p<0.001$). A subsequent Tukey's multiple comparison of means revealed that the differences were located as follows: Conditions N/N, A/A, AN and N/A all resulted in superior recall compared to both random conditions R/R_5 and R/R_6 (all constrasts significant at $p<0.01$). No significant differences on recall score were found between conditions N/N, N/A, A/A and A/N.

DEPENDENT VARIABLES	F df=5,54	P	TUKEY'S MCOM SIGNIF. CONTRASTS	P
Recall Time	9.28	<0.001	$A/A > R/R_5$	<0.05
			$N/A > R/R_5$	<0.01
			$A/N > R/R_5$	<0.05
			$R/R_6 > R/R_5$	<0.01
Recall Score	13.79	<0.001	$N/N > R/R_5$	<0.01
			$N/N > R/R_6$	<0.01
			$A/A > R/R_5$	<0.01
			$A/A > R/R_6$	<0.01
			$A/N > R/R_5$	<0.01
			$A/N > R/R_6$	<0.01
			$N/A > R/R_5$	<0.01
			$N/A > R/R_6$	<0.01

Table 2.13 F values and significant contrasts for the two dependent variables

In order to examine the relationship between the two dependent variables, Pearson product moment correlation coefficients were calculated between subjects performance on the two dependent measures at each of the six experimental conditions. These correlations and associated probabilities are shown in Table 2.14.

It can be seen from Table 2.14 that two correlations were significant. Within the matched condition A/A a significant negative correlation was detected between subjects recall time and recall score (r = -0.78,

	CONDITION					
	1 N/N	2 N/A	3 A/A	4 A/N	5 R/R_5	6 R/R_6
r	-0.32	-0.60	-0.78	-0.58	+0.78	-0.21
p	n.s.	n.s.	<0.01	n.s.	<0.01	n.s.

Table 2.14 Correlations between recall time and recall score in the six experimental conditions

df = 8, $p<0.01$). Within this condition it appears that subjects who recall the set of items faster tend to correctly recall more items. This might suggest that in this matched A/A condition, subjects need to restructure the input sequence less to meet the required output sequence. Within the matched random condition R/R_5 a significant positive correlation was detected between subjects recall time and recall score ($r = +0.78$, df = 8, $p<0.01$). Within this condition it appears that subjects who take longer to recall a set of items tend to correctly recall more items. Since this significant positive correlation is not found with the mismatched random condition R/R_6 ($r = -0.21$, df = 8, n.s.) one explanation might be that some subjects in the matched random condition R/R_5 are able to take advantage of the sequential correspondence between items at input and output and are able by spending time at recall to improve their number of correctly recalled items.

Discussion and conclusions

For the textual materials of the type used in the present experiment the results (see Table 2.12) show that matching acquisition and recall sequences by either concept name (condition N/N) or concept attribute (condition A/A) has a beneficial effect on recall scores compared with the random conditions (R/R_5 and R/R_6) where this form of categorical organisation is not apparent. There are, however, no significant differences in recall scores between the matched conditions (A/A and and N/N) and the mismatched conditions (A/N and N/A) (see Table 2.13 In fact the mismatched treatments A/N and N/A also result in superior recall scores compared with the random conditions R/R_5 and R/R_6. It appears that any categorical organisation inherent at acquisition and recall can be better utilised by subjects than either the sequential correspondence of items in treatment R/R_5 or the random sequences at acquisition and recall in treatment R/R_6. The significant positive correlation between recall time and recall score detected within treatment R/R_5 but not within treatment R/R_6 (see Table 2.14) might suggest that some subjects can take advantage of the sequential correspondence of items at input and output although this form of materials structure is clearly not as potentially useful as categorical organisation.

The results also show that the suggestion by Schultz and Di Vesta (1972) that passage organisation by concept name structures the subjects-task in a way which requires fewer associations for learning than passage organisation by concept attribute has not been supported insofar as recall score is viewed as a measure of learning difficulty. No significant differences were found either for recall score or recall time among treatments N/N, A/N or N/A (see Table 2.13). The specific prediction that N/N > N/A > A/N for recall score has not been supported. However, it is apparent from Table 2.13 that subjects in the matched N/N condition, unlike subjects in any other condition, do not take significantly longer to recall items than subjects in the matched random condition R/R_5.

In extending the results of the previous experiment (Experiments 1 and 2) to materials more analogous to normal instructional text, it is apparent that although any imposed categorical organisation at acquisition and recall can enhance recall performance compared with random treatments. However, unlike the results of Experiment 2, matched treatments do not result in better performance at recall than mismatched treatments. When subjects read textual material they are less constrained in the order in which they choose to select and attend to parts of the text. In the present experiment despite categorical organisation of passages, subjects can exercise more sequential choice than with the item presentation of the previous experiments (Experiments 1 and 2). Consequently, they might be more inclined to adopt an acquisition strategy in which they structure their input by selecting and attending to sentences in their preferred sequence rather than in the passage sequence. However, even if subjects were restructuring the input sequence along their preferred dimensions then they could still be faced with a mismatched imposed sequence at recall, since during the acquisition phase subjects were not aware of the output sequence required of them at recall. If this restructuring is occurring at input then the effects of matched and mismatched treatments would not be clearcut and consequently there would be no significant differences among the treatments N/N, A/A, A/N, N/A (as seen in Table 2.13). Clearly further experimentation is required to fully understand the complex interaction between input sequence, output sequence, and performance at acquisition and recall.

2.5 DISCUSSION OF UNIT 1 (EXPERIMENTS 1, 2 AND 3)

Three experiments were presented in Unit 1 which attempted to examine how the processes of learning are influenced by the sequence and organisation of instructional materials. Relevant research has been introduced in the introduction to the unit (Section 2.1). The purpose of this discussion is to summarise the main results of the unit in relation to cognitive structures, strategies and instruction.

2.5.1 Organisation and process in the experiments of Unit 1

A number of experimental procedures have been used in order to either explicity or indirectly manipulate the information-processing activities of learners in order to enhance learning from text. This type of research is valuable since it may lead to specific recommendations for improving textual materials. One approach has been to provide information about a text's structure or organisation in the form of outlines, headings or topic sentences. These adjunct or organisational aids attempt to highlight the relationships among the various informational units of a text such that the superordinate ideas can be used to facilitate recall of subordinate information.

The point has been made previously (1.4) that the type and organisation of instructional content is an important consideration for both the application of a learners cognitive strategies and the design of instruction. Previous researchers (Schultz and Divesta, 1972) have reasoned that when the learner relies on a passage organisation consistent with his dominant clustering strategy during learning, he would employ that organisational mode during recall with the effect of facilitating what is remembered. However, when a passage organisation is inconsistent with the learner's dominant strategy, then the strategy normally employed must be relinquished, and as a consequence a different less well-practised strategy must be employed to the detriment of recall.

The theme of the experiments in Unit 1 has been to examine in more detail, the contention that if information is structured and presented in a form consistent with the learner's current knowledge and skills then learning should be enhanced. The experiments have attempted to shed light on two main issues which are apparent in this type of research.

The first issue relates to previous assumptions (eg Frase,1969; Schultz and Divesta, 1972) that clustering at recall was an adequate measure of subjects' organisational processes using instructional materials of the type used in Unit 1. A number of studies (eg Bjorklund et al, 1977; Corsale & Ornstein, 1977; Puff, Murphy and Ferrara,1977) have generally indicated inconsistencies between the use of an organisation at stimulus input and the use of an organisation at response output. The relationships among input organisation, output organisation and performance at recall appear to be complex.

The second issue relates to attempts to extend research findings derived from list learning tasks to experiments involving materials more analogous to conventional instructional text. When more complex textual material is used as the instructional content, the use of subjects organisational strategies in structuring "items" at input and output become more dependent on subjects prior knowledge of organisational structures implicit in the instructional materials.

In conventional list learning experiments, the overall categorical organisation is probably uncovered through "data-driven" processing during the course of presentation of the material. When learning from textual materials, learners' advance knowledge and expectations of common event sequences probably operates as "conceptually-driven" processing by structuring and giving meaning to incoming information(J.M.Mandler, 1979). Organisational aids should therefore be particularly beneficial if the instructional material is such that the learner cannot uncover the structure of the instructional materials without them. Much of the research on organisational aids has proceeded on an intuitive basis and relies on the competence of the person engaged in the analysis. This competence relates not only to the analysis of instructional content but also to the judgement of the learners pre-requisite knowledge and skills and the mapping of the organisers both onto the instructional context and the learners pre-requisite knowledge and skills. Theoretical efforts in understanding both cognitive structure and cognitive strategies are crucial in attempts to improve instructional methods and materials.

The methodology for handling the instructional content in the experiments of Unit 1 was to construct materials onto which clearly defined alternative modes of organisation could be imposed. The instructional content was constructed from simple sentence "units" which expressed an association between a concept name, a concept attribute, and a concept attribute value. The sentences could be categorically clustered by concept name, concept attribute or randomly. In Experiment 1 the concept names and concept attributes were the superordinates and the concept attribute values were designated by numbers. Two versions of the materials were constructed which differed only in the concept attribute values. These materials were used in what were referred to as tasks 1 and 2 and all subjects did both tasks.

The results of Experiment 1 showed that subjects were inclined to change their acquisition and recall clustering strategies both within and between the two tasks. One particularly interesting finding was that subjects were more inclined to change their acquisition clustering strategies at their second encounter with the task (task 2). The effect of this was to significantly increase their concept name clustering correspondence at task 2 (i.e. the degree to which clustering by concept name was utilised at both the acquisition and recall phases). This high concept name clustering correspondence at task 2 was significantly correlated with amount recalled. Amount recalled at task 2 was significantly greater than amount recalled at task 1.

These results are interesting since they suggest that not only are specific transfer effects operating between task 1 and 2, but also non-specific transfer effects are operating. The specific transfer effects probably stem from subjects greater familiarity with the superordinate concept name and concept attribute organisational labels. The change in subjects' acquisition clustering strategies at task 2 (i.e. the manner in which subjects sequentially select and attend to the instructional material) might suggest that subjects are using task 1 as an illustration of how to carry out organisational processes so as to effect greater proficiency in recall performance at task 2.

Further the finding that only concept name clustering correspondence and not concept attribute clustering correspondence was associated with amount recalled at task 2 might reflect subjects' prior knowledge relating to their expectation that concept name clustering is more frequently employed than concept attribute clustering in most instructional material. It might be that having uncovered the structure of input at task 1, then possibly at task 2 subjects are able to bring their previously acquired knowledge to bear on their strategic manipulations of the instructional materials at task 2.

In Experiment 2, using the same two sets of instructional materials as in Experiment 1 (and specified as task 1 and task 2), performance was investigated under conditions where the correspondence between input and output sequences was experimenter rather than learner controlled. The results suggested that subjects were generally unable to discover the organisational structure when items were randomly presented and randomly recalled as evidenced by the low recall in these conditions. However, the results generally supported the hypothesis that matching organisation at input and output (clustered by concept name or concept attribute) resulted in superior recall compared with random conditions. This result is consistent with a subsequent experiment performed by Ornstein and Corsale (1979) who suggested that output organisation might be maximally effective when it reflects an organised search of the structures established at input.

No significant difference in amount recalled was detected between the experimental condition in which the organisation at input and output was matched by concept name and the experimental condition in which the organisation at input and output was matched by concept attribute. Although this result did not support the contention that subjects previously acquired knowledge structure included a simple event schema concerning the expectation of the organisation of instructional material, two other measures revealed differences between the two categorically matched treatments. Recall time was significantly faster for the matched organisation by concept name treatment at task 2 compared with recall time for the matched organisation by concept attribute treatment at task 2. In addition, there was a highly significant negative correlation between recall time and recall score for items in the matched organisation by concept name treatment at task 2, whereas this was not the case for items in the matched organisation by concept attribute treatment at task 2. These results might be tentatively interpreted to suggest that with familiarity with the superordinate category names gained at task 1, at task 2 their previously acquired expectation of instructional organisation can facilitate performance.

Experiment 3 extended the findings of Experiments 1 and 2 by examining organisation and recall performance when subjects were learning from materials which were presented as passages rather than as discrete "items". In this way the materials were more analogous to normal instructional text. As in Experiment 2 the organisation at input and output was experimenter controlled. The results showed that any imposed categorical organisation at acquisition and recall (matched or mismatched) resulted in superior recall scores compared with the randomly sequenced treatments. These results contrasted with those of Experiment 2 where categorically mismatched treatments resulted in significantly no better recall scores than random treatments. The difficulty in interpreting the difference between the pattern of results in Experiment 2 and Experiment 3 stems from the fact that subjects can exercise more sequential choice in selecting and attending to information that is presented as passages compared with information that is presented as a sequence of items. In Experiment 3 irrespective of the organisation of sentences within passages, subjects might be inclined to adopt an acquisition strategy in which they structure their input by selecting and attending to sentences in their preferred sequence rather than in the passage sequence.

This is an interesting observation insofar as the implicit organisation of textual material might not result in manipulating learners processing activities, if learners preferred acquisition sequences deviate from the textual sequence. As G. Mandler (1979) has pointed out, structure at input predicts nothing about the acquisition process. Even if uncovered the structure of instructional material may not be utilised by learners. Even with explicit organisational aids to highlight the structure of material, learners may not utilise the specified structure. Consequently in attempting to optimise the structure and sequence of instructional material an understanding of learners' knowledge, skills and intentions is critical.

2.5.2 Conclusions

Using instructional material onto which alternative modes of organisation can be imposed and manipulating task variables in order to observe their effects on subjects' strategies is a useful way in which organisational processing can be investigated. The experiments have demonstrated that the relationships between input organisation, output organisation and recall are complex, and both acquisition and recall strategies are important in understanding organisational processing. The role of subjects' prior knowledge and skills and their relation to instructional materials are critical in the experiments described.

Contemporary organisational theory can be expanded to embrace the cognitive perspective and experimentation of the type reported in Unit 1 illustrate that this might prove to be a fruitful union in attempting to specify an adequate process model of organisation, memory and instruction.

2.6 INTRODUCTION TO UNIT 2

Experiments attempting to examine the nature of various cognitive structures and processes have generally fallen into one of two classes. One class of experiment has examined the processes involved in the acquisition, storage and retrieval of an artifical body of knowledge presented during the experimental session. The three experiments in Unit 1 have been of this type.

A second class of experiment has not presented any new information but instead has attempted to examine subjects' existing knowledge of the world. These experiments have generally measured the amount of time required to retrieve information from semantic memory. An approach which combines aspects of both classes of cognitive structure research might be appropriate in investigating the central issue of how new information is integrated with old (Potts, 1975).

One way of combining both classes of research has been devised and utilised in experiments 4, 5 and 6 of unit 2. Unknown categories (designated by CVC's) are included in pairs of quantified premises to give stimulus items like:

All DOGS are PAQ

All PAQ are animals

The subject's task is to infer the relationship of the unknown category ("PAQ") to both of the known categories ("DOGS" and "ANIMALS") and to diagram (by drawing three circles) the set-relationships among the three categories. In order to do this it is apparent that subjects must use both their existing knowledge and the presented information. The methodology used in experiments 4, 5 and 6 is discussed further in Section 2.6.2. A set-theoretic approach to semantic representation is used and the next section (2.6.1) considers this area in more detail.

The structure of the experimental materials, the cognitive structures of the individual, and the strategies he uses in the experimental situation were important factors in the experiments of Unit 1. The experiments of Unit 2 represent another context in which these three critical components can be examined.

2.6.1 General theoretical background to experiments 4, 5 and 6

In this section set-theoretic models of semantic memory are briefly discussed in relation to other approaches. The importance of distinguishing the structure of knowledge from strategies of information processing is noted, and logical and psychological models of inference are contrasted.

Collins and Quillian (1969) have suggested that when two terms are compared at different levels in the internal hierarchy, subjects are forced to traverse intervening concepts. Thus, evaluating the statement "a canary is an animal" takes longer than evaluating the statement "a canary is a bird" ("bird"would be an intervening concept in evaluating "a canary is an animal"). However, several alternative explanations can be proposed. Schaeffer and Wallace (1969) have suggested that the two presented words are coded into attributes and subjects compare the words directly by attempting to discover overlaps between the set of attributes. Such searches take longer with "animal" and "canary" for example, than with "bird" and "canary" because the subjectively prominent attributes into which "animal" is coded might be quite different from those into which "canary" is coded. Schaeffer and Wallace suggest that if "bird" shares more prominent attributes with "canary" than "animal" does, then overlaps for "canary" and "bird" will be easier to find and evaluation quicker.

In set-theoretic models of semantic representation, verification occurs by searching through sets and not by traversing links as in the Collins and Quillian (1969) model. Therefore, differences in subjects' response times when two terms are compared are attributed to category size and not to semantic distance. In set-theoretic models concepts which share any descriptive features or properties may form intersecting sets (i.e.  set overlap) or one set may be included within another (i.e.  set inclusion). If concepts do not share any features or properties then they are non-intersecting sets (i.e.  set exclusion). Several authors have proposed models of semantic memory which characterise conceptual knowledge in terms of sets of properties, attributes or features (e.g. Rips, Schoben and Smith, 1973; Smith, Schoben & Rips, 1974). Meyer (1970) observed differences in response times when subjects judged "All" or "Some" quantified statements as true or false, and proposed a two-stage process for retrieving information from a set-theoretic model. Stage 1 consists of checking for an intersection between the sets and Stage 2 consists of searching through the intersection. Since there is no intersection between false statements of both the "All" or "Some" type, they can both be rejected equally fast at Stage 1 without needing to proceed to Stage 2. "Some" true statements are associated with faster response times than "All" true statements since in the verification of the latter, subjects need to proceed to Stage 2.

A number of psychologists have explored set-theoretic interpretations of quantified assertions arranged as syllogisms (e.g. Ceraso and Provitera, 1971; Erickson, 1974; Neimark and Chapman, 1975). The set-theoretic model proposed by Erickson was the first explicit attempt to specify the processes involved in syllogistic inference. In this approach the assumption is that syllogistic errors stem from subjects failing to consider all of the possible representations. Johnson-Laird and Steedman (1978) have criticised set-theoretic representations on the grounds that "Some" or "No" quantified statements are symmetrical. These authors have reported performance differences between identical syllogisms in which the position of the terms in "No" and "Some" premises are varied. This so-called 'figural effect' appears to pose problems for any symmetrical representation of "No" and "Some" premises and Johnson-Laird and Steedman (1978) have postulated a theory in which quantified assertions receive a directional mental representation. However, these results may well be reflecting particular processing strategies rather than the underlying structure of knowledge. Rips (1975) has observed that in verification tasks the speed of responses varies when "Some" is interpreted as "some but not all" and this suggests that particular strategies of knowledge retrieval are operating. Wickelgren (1979) has noted the difficulty people have in interpreting quantified assertions and has suggested that verifying an "All" or "Some" statement requires subjects to use "inference plans". Although the quantifiers "All" and "Some" are basic to predicate logic, Wickelgren suggests that unquantified thinking appears to be basic to human semantic memory. Whereas in logic one might say "some birds can fly" or "all birds can fly", humans typically say "birds can fly" meaning essentially "most birds can fly". Therefore, unlike the verification of "All" and "Some" statements in which inference plans are required, verifying an unquantified statement like "birds can fly" might be a simple direct access recognition process.

The consideration of logic systems as models of human thinking has a long history in psychology. However, recent research suggests that there are clear differences between "mathematical logic" and"human logic". Logic is the science of the form of an argument without respect to its content, but it is becoming increasingly clear that it is impossible to study "pure" reasoning uncontaminated by a subject's prior knowledge. In fact the central question appears to be how new information is incorporated into a prior knowledge structure. Experiments 4, 5 and 6 attempt to explore some of these dynamics of processing using a set-theoretic approach and pairs of quantified assertions as a vehicle. The particular methodology employed is described in the next section.

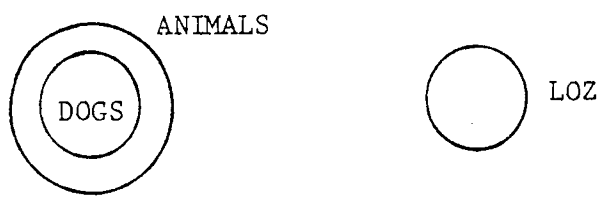
2.6.2 <u>The diagramming relationships methodology</u>

In order to describe the particular methodology involved in experiments 4, 5 and 6, consider an example of a stimulus item (used in one condition of experiment 4),

No LOZ are DOGS

No ANIMALS are LOZ

It can be seen that the stimulus item consists of two premises and three categories. In this item there are two known categories ("DOGS" and "ANIMALS") and one unknown category (designated by the CVC, "LOZ"). Using the relationship between the two categories already known to them, the subjects' task is to draw the Venn diagram representing the correct set relationships among the three categories. For the above item example, the correct solution is:



The relationship of the two known categories in the example is one of set-inclusion (S) but in other stimulus items this relationship might be one of set-overlap (O) or set-exclusion (E).

Fig. 2.4 summarises the premise types which can occur in stimulus items and shows their associated correct diagrams. The conventional logical notation A, E and I is used in Fig. 2.4 to refer to "All" "No" and "Some" premises respectively. The letters X and Y represent the two categories in a premise. For the sake of simplicity the O premise (Some X are not Y) is never included in stimulus items.

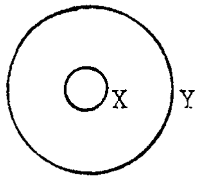
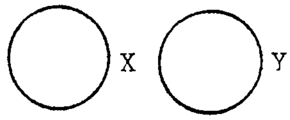
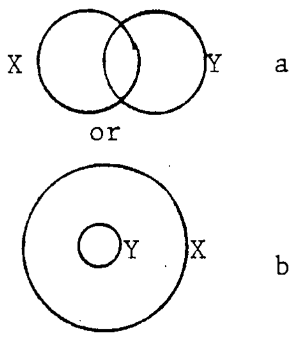
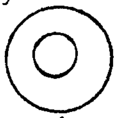
NOTATION	PREMISE	CORRECT DIAGRAM
A	"All X are Y"	
E	"No X are Y"	
I	"Some X are Y"	

Fig. 2.4 Premises and correct diagrams

In mathematical logic "Some" includes "All" as a possibility. Wickelgren (1979) has observed that in most cases when humans say "Some" they mean to exclude "All" as a possibility. In natural language "some birds can fly" is virtually always taken to mean that "some birds cannot fly" otherwise the person would have made the unquantified statement "birds can fly" or the stronger quantified statement "all birds can fly". In accordance with the conventions of natural language it can be seen from Fig. 2.4 that the stronger quantifier "All" is used rather than "Some", wherever possible, in a premise.

The diagrammed representation of a "Some" premise may either be of the symmetrical form (i.e.  a) or the non-symmetrical form (i.e.  b - see Fig. 2.4). The representation of the "No" premise is always symmetrical (i.e. the representation for "No X are Y" is identical to the representation "No Y are X").

The unknown category (U) always occurs in both premises of a stimulus item and the possible arrangement of known (K) and unknown categories within stimulus items are shown below. These arrangements can be described by the traditional syllogistic variable of "figure".

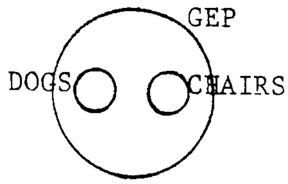
U - K	K - U	U - K	K - U
K - U	K - U	U - K	U - K
Figure 1	Figure 2	Figure 3	Figure 4

Any stimulus item can therefore be conveniently identified by combining the notation for premise type (A, E or 1) with the notation for "figure" (1, 2, 3 or 4) and the set-relationship of the two known categories (S, O or E). Using this notation stimulus item A/A/2/E could be for example:

All DOGS are GEP

All CHAIRS are GEP

and would be correctly diagrammed as:



The combination of premise types (e.g. the A/A part of the A/A/2/E notation above) is conventionally referred to as the "mood" of a syllogism.

Although the stimulus items in the diagramming relationships task can be partly described by the conventional syllogistic variables of "mood" and "figure", there are a number of important differences between the traditional syllogistic reasoning task and the diagramming relationships task. The primary difference is that in the diagramming relationships task, subjects are required to use both their knowledge of the known categories and the premise information. In other words both content and form are stressed rather than just form as in the traditional syllogistic reasoning task. Another difference relates to the required response. In the present methodology, subjects are not merely required to infer a conclusion from the presented pair of premises (as in a conventional syllogistic task) but must diagram the relationships among the three presented categories.

Experiment 4 is a preliminary study which identifies some of the performance differences associated with this task in order to evaluate the feasibility of the diagramming relationships methodology as a vehicle for examining some aspects of the dynamics of cognitive processing. The strategies which subjects adopt when they are incorporating a new category into their prior knowledge structure are emphasised.

Experiment 5 uses the categories in stimulus items of one condition in Experiment 4 and examines the differences between a "quantified" presentation of categories and an unquantified "list" presentation of categories.

Experiment 6 extends the findings of Experiment 4 and examines the effects of instructing subjects to use particular diagramming sequences in order to induce subjects to use effective cognitive strategies.

2.7 EXPERIMENT 4 : DIAGRAMMING RELATIONSHIPS - THE INCORPORATION OF NEW CATEGORIES INTO A PRE-EXISTING COGNITIVE STRUCTURE

Introduction

Evans (1978) has concluded from a review of propositional reasoning that there is an abundance of evidence that the comprehension of sentences forming the premises of arguments has a considerable influence both at the syntactic and semantic level. Inferences are continually drawn from the information stored in semantic memory which allow the generation of novel propositions and the judgement of whether or not they are true. Clearly, an individual's cognitive structure provides a framework into which linguistic inputs fit and are dependent on that framework to make sense (Rumelhart, 1977). Potts (1975) has suggested that the key to comprehension lies in the successful incorporation of new information into a pre-existing cognitive structure. However, very little empirical work has directly focused on this question which clearly has important implications for instructional design.

A methodology has been described previously (section 2.6.2) that provides a framework in which some of those aspects of cognitive processing which allow the incorporation of unknown categories into an individual's knowledge base, can be examined. In this preliminary experiment, it is hypothesised that the structure of subjects' prior knowledge about two known categories in a stimulus item (specified in set-theoretic terms) will effect the difficulty (measured by speed and accuracy) of subjects comprehending the stimulus items.

Further, it is assumed that the sequence in which subjects diagram the circles representing the stimulus item categories will reflect cognitive strategies which control and direct the processes by which unknown categories are incorporated into a subject's prior knowledge. These cognitive strategies may be akin to the "inference plans" suggested by Wickelgren (1979). These "inference plans" may be necessary in order to evaluate any overlap discovered between the features or properties of the categories in the stimulus items. This evaluation is necessary in order that the appropriate set-relationships between categories can be diagrammed.

Method

Design and materials: Stimulus items consist of pairs of quantified premises. As previously described (section 2.6.2) an item type can be identified by specifying the "mood" of the premise pair, the "figure" in which the premises are cast, and the set-relationship of the two known categories in an item. Figure 2.5 gives all the possible correct diagrams (when one category is unknown) for the four "figures" in each of the three selected "moods" under the three conditions of relationship of the two known categories. It can be seen from Figure 2.5 that the same quantifier was used for both premises in any stimulus item (i.e. in logical notation, selected "moods" were A/A, I/I, E/E). In Figure 2.5 a blank cell signifies that no correct diagram is possible, bearing in mind that in this task, set identity is not allowed (i.e. there are always three circles in a correct diagram) and that the stronger quantifier "All" is always used in a premise wherever possible, in preference to the quantifier "Some". In Fig. 2.5 the two known categories (K) for a correct diagram are presented by "light" circles and the one unknown category (U) for a correct diagram is represented by a "heavy" circle.

KEY (to Fig. 2.5)

O ≡ set-overlap known category relationship

E ≡ set exclusion known category relationship

S ≡ set inclusion known category relationship

(O) ≡ known category (light circle)

(O) ≡ unknown category (heavy circle)

A ≡ 'All' premise

E ≡ 'No' premise

I ≡ 'Some' premise

U ≡ unknown category

K ≡ known category

(For set-inclusion relationship between known items, the subset component was always included in the first premise.)

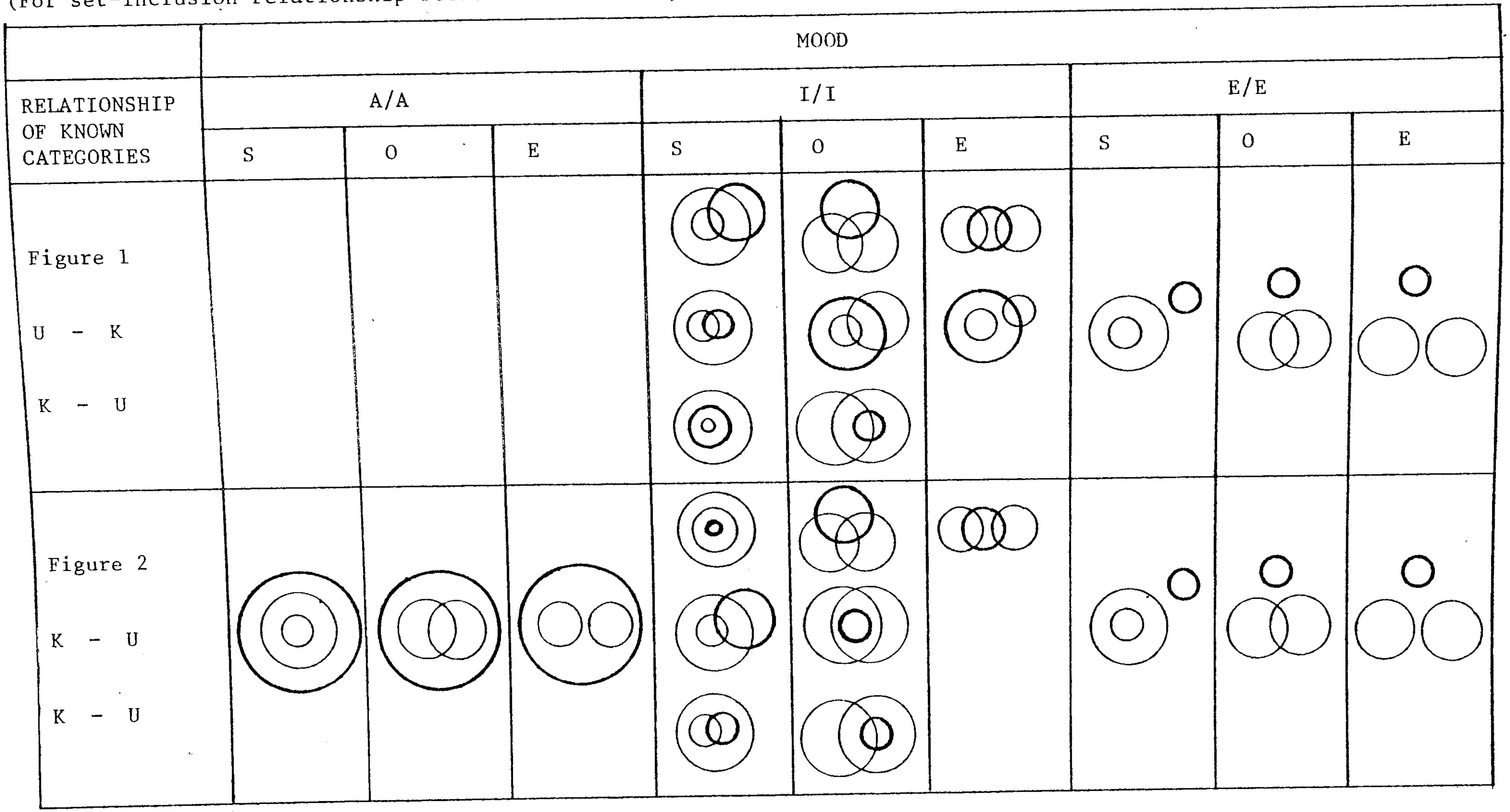


Fig. 2.5 Possible correct diagrams for 3 selected moods, 4 figures and 3 set-relationships of the 2 known categories and one unknown category

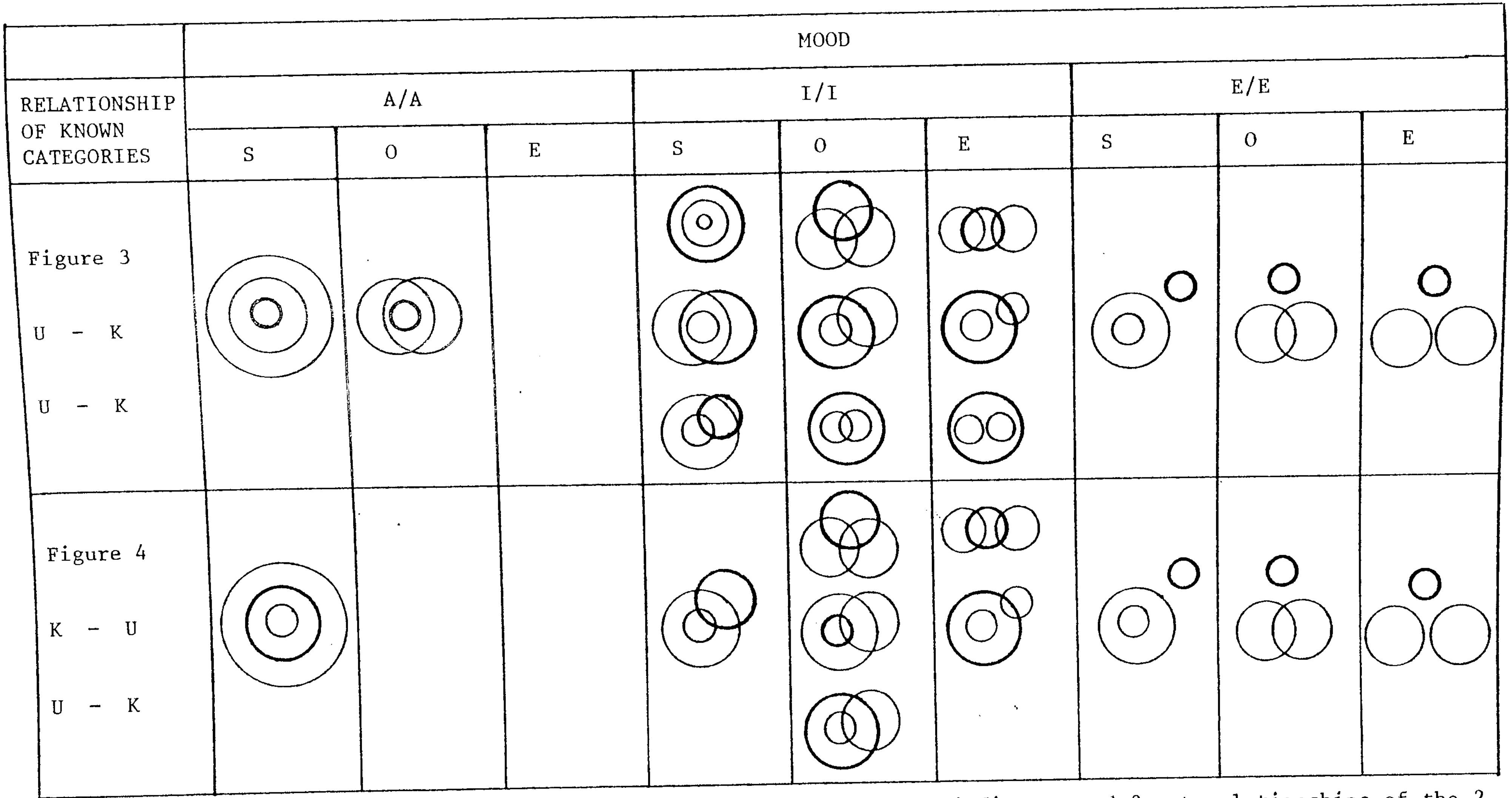


Fig. 2.5 continued Possible correct diagrams for 3 selected moods, 4 figures and 3 set-relationships of the 2 known categories and one unknown category

Syllogistic type can be identified by combining the variables of "mood" and "figure". Of the twelve syllogistic types (e.g. A/A/1, I/I/4, E/E/3, etc.) included in Fig. 2.5, three were selected (A/A/2, I/I/4, and E/E/1). For each of the three syllogistic types selected, the set-relationship of the two known categories could be one of set-inclusion (S) set-overlap (O) or set-exclusion (E). There are therefore nine item types (e.g. A/A/2/S, I/I/4/E, E/E/1/S, etc.) and these are shown in Fig. 2.6 together with the associated correct diagrams. In Fig. 2.6 below, the known categories (K) are represented by "light" circles and the unknown categories (U) by "heavy" circles.

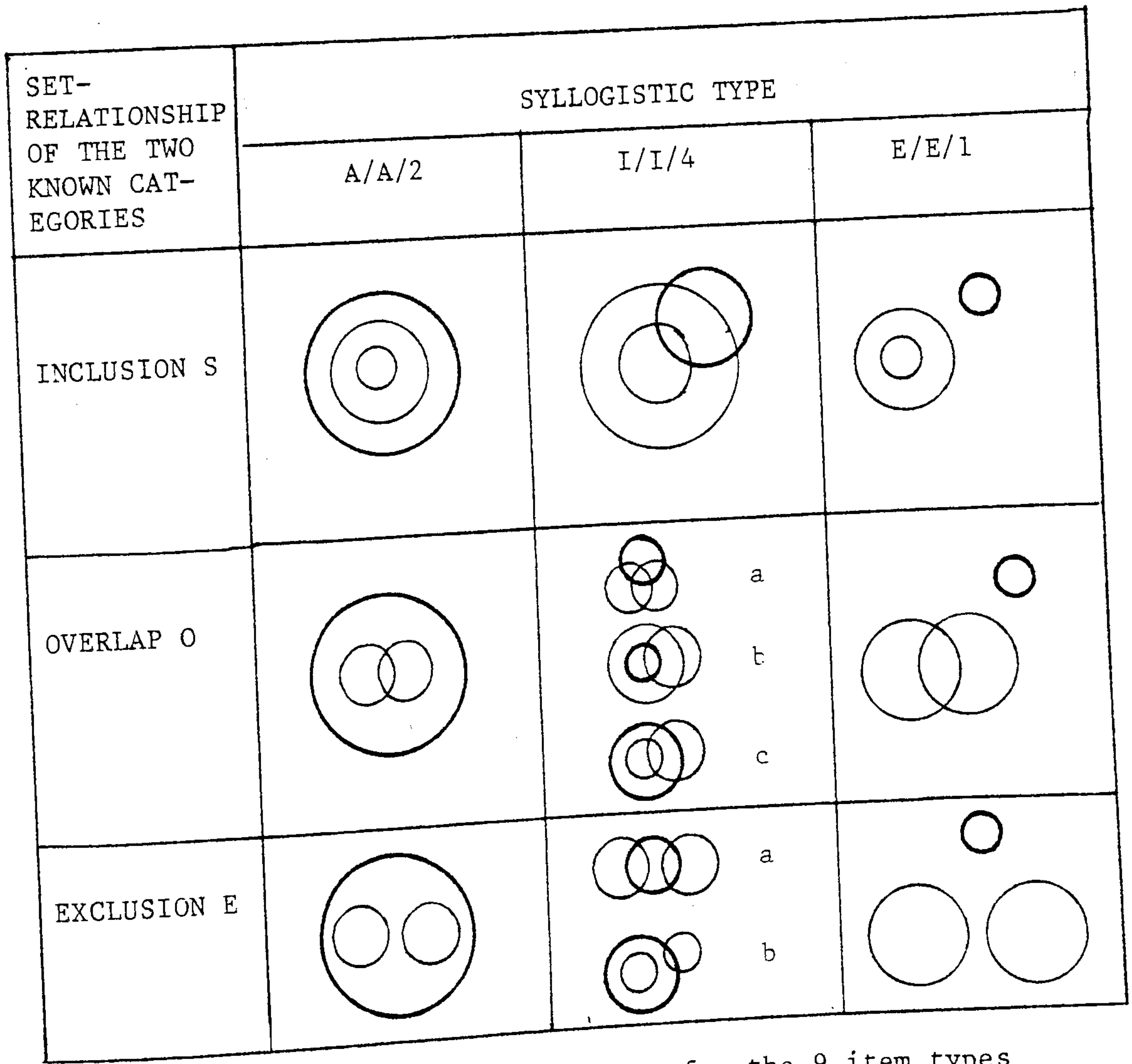


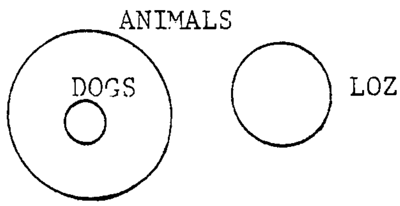
Fig. 2.6 Possible correct diagrams for the 9 item types

For one of the stimulus items, the item type E/E/1/S took the form:

No LOZ are DOGS

No ANIMALS are LOZ

and would be correctly diagrammed as:

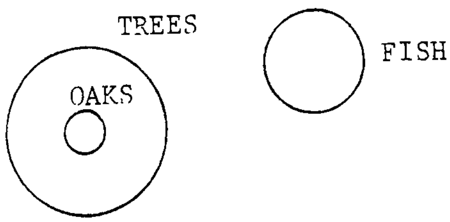


For each of the nine item types, two stimulus items were generated to give eighteen stimulus items containing two known and one unknown category. In addition eighteen "matched" items, where all three categories were known, were also generated. The equivalent "matched" stimulus item to the E/E/1/S example above took the form:

No FISH are OAKS

No TREES are FISH

and would be correctly diagrammed as:



There were, therefore, 36 stimulus items in all, and all categories in these stimulus items occurred with a frequency of at least 50 per million (i.e. A and AA words in Thorndike and Lorge, 1944).

It can be seen from Fig. 2.6 that for item type I/I/4/O there are three possible correct diagrams, when an unknown category is included in a stimulus item. Consequently, there are three possible "matched" stimulus items (when three known categories are included). Similarly, for item type I/I/4/E there are two possible "matched" stimulus items. A pilot study revealed that diagrams I/I/4/O/b and c and I/I/4/E/b were never drawn. Diagrams I/I/4/O/a and I/I/4/E/a were therefore used in generating "matched" stimulus items.

Each of the 36 stimulus items was printed on a card and the presentation order randomised for each subject. All items were presented to all subjects.

For ease of description, stimulus items which contain two known categories and an unknown category are subsequently referred to as "unknown items" and stimulus items which contain three known categories are subsequently referred to as "known items". Syllogistic types are labelled A/A/2, I/I/4 and E/E/1 as described previously, and these labels are used in the subsequent sections of the experiment. The set-relationship of the two known categories in unknown items is subsequently referred to as "category relationship in unknown items". The set relationship of the equivalent two known categories in known items is subsequently referred to as "category relationship in known items". If a particular category relationship is referred to it is identified as S (set-inclusion), O (set-overlap) or E (set-exclusion). The category which is designated by a CVC in unknown items is subsequently referred to as an "unknown category" and the category which is in the equivalent position in known items is subsequently referred to as an "unknown category equivalent".

Subjects: Ten students from the Faculty of Social Sciences & Humanities, University of Aston in Birmingham were randomly selected to serve as experimental subjects.

Procedure

The subjects were tested individually. On entering the test room each subject was asked to read carefully a set of instructions about the diagramming relationships task. Subjects were asked "to use your knowledge of the groups you know and the information in the items to draw the correct relationship". The order of presentation of items was randomised for each subject. After being presented with each test item in turn, the subjects' task was to draw the correct diagram on the paper provided. Subjects were timed by the experimenter for each diagram and were instructed to work as quickly as possible without making any errors. Subjects were instructed to cross out any incorrectly drawn diagram and to redraw the correct one if they spotted a mistake. When they were satisfied with their diagram subjects were instructed to say "right" as a signal to the experimenter to stop the stopwatch. While the experimenter noted the diagramming time for each item, subjects were instructed to mark each of the three circles in the diagram they had just drawn with a 1, 2 or 3 to show the order in which they were drawn, and also to label each circle with the category name associated with it.

All subjects were given five practice items to familiarise them with the experimental procedure during which any questions were answered by the experimenter. It was made clear that there was always at least one correct solution for each item, and the necessity of using the knowledge of relationships of known categories in each item was stressed. A copy of the verbatim instructions is given in Appendix 6(d).

Dependent variables

(i) Diagramming time for each item

(ii) Errors for each item

Each stimulus item contains three categories. Consequently, any category can have one of three set-relationships (either S, O or E) with the other two categories in a stimulus item. For any of the three category pairs in a stimulus item, subjects can make two types of error, and there are therefore six possible error types in all. The error types are labelled a to f and are shown in Fig. 2.7.

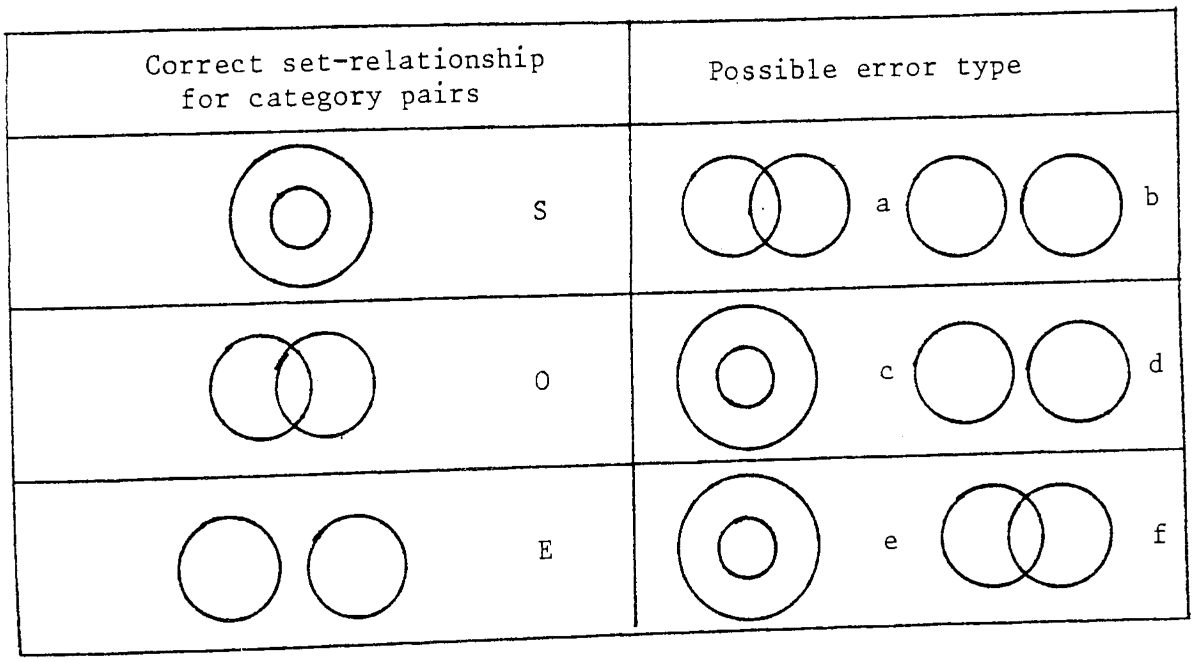


Fig. 2.7 Possible error types for category pairs in the diagramming relationships task

All diagrams contain three circles (representing the three categories in a stimulus item) and any incorrectly diagrammed stimulus item may contain either 1, 2 or 3 error types and these were determined, when appropriate from subjects' diagrams.

The a priori probability of error types

Each of the correct diagrams (see Fig. 2.6) can be described by the number of S, O or E set-relationship for category pairs it contains. Excluding alternative diagrams (I/I/4/O/b, I/I/4/O/c and I/I/4/E/b - which subjects never diagrammed in the pilot study) it can be seen from Table 2.15 that summed across diagrams each set-relationship for category pairs occurs with an equal frequency. Consequently the a priori probability of error types a - f is identical.

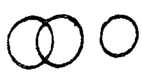
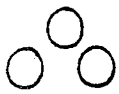
Item type	Correct diagram	S	O	E
A/A/2/S		3	0	0
A/A/2/O		2	1	0
A/A/2/E		2	0	1
I/I/4/S		1	2	0
I/I/4/O		0	3	0
I/I/4/E		0	2	1
E/E/1/S		1	0	2
E/E/1/O		0	1	2
E/E/1/E		0	0	3
	Σ	9	9	9

Table 2.15 S, O and E set-relationships for 10 correct diagrams

(iii) Output order of circles for each diagram.

It was expected that this information could shed light on some of the processes involved in the diagramming relationships task.

Results

The results are dealt with in two main sections. In the first section diagramming times on unknown and known stimulus items are examined. As described previously an unknown stimulus item is one which contains two known categories and one unknown category, and a known stimulus item is one which contains three known categories. In the second section subjects strategies and diagramming errors are examined for both unknown and known stimulus items. A results summary is included at the end of this section.

Diagramming time

(i) Diagramming time for unknown items

In order to examine the effects of syllogistic type and category relationship in unknown items on subjects' diagramming times, a randomised block factorial analysis of variance (RBF 3x3, Kirk, 1968) was calculated. The analysis of variance summary table is given in Appendix 3 (Table a). Although this is a mixed model (the syllogistic type and category relationship in unknown items treatments are both fixed effects and blocks (subjects) are random) it is not necessary to assume that block and treatment effects are additive in order to test the treatment effects (Kirk, 1968; p. 137) although blocks can be seen Table a, Appendix 3) to have a significant effect on diagramming times ($F = 4.02$, $df = 9,72$; $p<0.01$). The syllogistic type X category relationship in unknown items interaction in this analysis was significant ($F = 2.54$, $df = 4,72$; $p<0.05$), and consequently, there is little interest in the main effects. A simple main effects analysis of variance was therefore calculated and this summary table is given in Appendix 3 (Table b). This analysis revealed that only within syllogistic types A/A/2 were there any significant effects. A multiple comparison of means procedure (Tukey's HSD test) revealed that within syllogistic type A/A/2, stimulus items which contained set-overlap (O) category relationships took longer to diagram than stimulus items which contained either set-exclusion (E) category relationships ($p<0.01$) or stimulus items which contained a set-inclusion (S) category relationships ($p<0.05$). Stimulus items which contained set-inclusion (S) category relationships did not result in significantly different diagramming times than stimulus items which contained a set-exclusion (E) category relationship.

(ii) Diagramming time for known items

In order to examine the effects of syllogistic type and category relationship in known items on subjects diagramming times, a randomised block analysis of variance (RBF 3x3; Kirk, 1968) was calculated. The analysis of variance summary table is given in Appendix 3 (Table c). It can be seen from Table c (Appendix 3) that blocks (subjects) have a significant effect on diagramming times ($F = 16.97$, $df = 2,72$, $p<0.001$) and category relationship in known items ($F = 7,38$, $df = 2,72$, $p<0.01$). The syllogistic type X category relationship in known items interaction was not significant ($F = 2.10$, $df = 4,72$, n.s.).

A multiple comparison of means procedure (Tukey's HSD test) was used in order to determine the location of differences within the two significant factors of syllogistic type and category relationship in known items. Table 2.16 summarises these results.

FACTOR	SIGNIFICANT CONTRASTS	p
Syllogistic type	I/I/4 > E/E/1	<0.01
(see Fig. 2.6)	I/I/4 > A/A/2	<0.01
Category Relationship	S > E	<0.05
in known items	O > E	<0.05
(see Fig. 2.6)		

Table 2.16 Significant contrasts within two significant factors for diagramming time in known items

It can be seen from Table 2.16 that for known items subjects experienced the greatest difficulty (as measured by diagramming time) when diagramming items of the syllogistic type I/I/4. Syllogistic types A/A/2 and E/E/1 resulted in similar diagramming times. For category relationship in known items, Table 2.16 shows that subjects took longer to diagram stimulus items which contained a set-inclusion (S) or a set-overlap (O) relationship compared with those stimulus items which contained a set-exclusion (E) relationship. No significant difference was found in diagramming time between those items which contained a set-inclusion (S) relationship and those items which contained a set-overlap (O) relationship.

(iii) Diagramming time and errors

Spearman's rho correlation coefficients were calculated between subjects mean diagramming time and errors for known items (ρ = 0.47, N = 10, n.s.) and unknown items ($\rho = 0.16$, N = 10, n.s.). It appears that subjects were not trading diagramming speed for errors.

Subject strategy and diagramming errors

(i) Diagramming sequence and errors for unknown items

For each diagram subjects draw, the unknown category can be drawn first, second or third (referred to as positions 1, 2 or 3). The frequencies of the unknown categories in positions 1, 2 and 3 for correct and incorrect diagrams are shown in Table 2.17 below.

		POSITION 1	2	3
Unknown items	Correct	74	1	70
	Incorrect	12	10	13

Table 2.17 Frequency of unknown categories in positions 1, 2 and 3 for unknown items

Friedman's two-way analysis of variance by ranks was calculated for both correct and incorrect diagrams. For correct diagrams $\chi^2_r = 15.20$ df = 2, $p<0.001$. Nemenyi's a posteriori test for multiple comparison of means (in Kirk, 1968) revealed that position 1 was used significantly more for the unknown category than position 2 ($p<0.01$) and position 3 was used significantly more for the unknown category than position 2 ($p<0.01$). No significant difference was detected between position 1 and position 3. For incorrect diagrams $\chi^2_r = 0.65$, df = 2, n.s.

It is apparent for correct diagrams that the unknown category tends to be dealt with more often at the beginning (position 1) or end (position 3) of subjects' diagramming sequences. For incorrect diagrams no significant positional differences were found. Subjects output sequences are related to their success at generating correct diagrams.

Consider the three output sequences in which subjects can diagram the two known (K) categories and one unknown category (U) for unknown items.

	POSITION 1	POSITION 2	POSITION 3
Output sequence 1	U	K	K
Output sequence 2	K	U	K
Output sequence 3	K	K	U

It can be seen from Table 2.17 that when subjects are correctly diagramming they almost always adopt either output sequence 1 or output sequence 3. If subjects are evaluating categories serially as pairs (i.e. evaluating category pair (1,2) before evaluating category pair (2,3))then in both output sequence 1 and output sequence 3 they are evaluating the set-relationship between the two known categories. When subjects are incorrectly diagramming, output sequence 2 is adopted as frequently as output sequence 1 or output sequence 3 (see Table 2.17). Output sequence 2 is probably primarily associated with incorrect diagrams because if subjects are evaluating categories serially as pairs then this sequence does not result in the known categories being evaluated. If subjects are evaluating categories serially as pairs then the tendency will be for subjects not to evaluate the remote set-relationship (1,3). Consequently, more errors should occur for the remote category pairs (1,3) than for the adjacent category pairs (1,2 and 2,3). Table 2.18 below gives the frequency of errors for adjacent and remote category pairs for unknown items.

	CATEGORY PAIR		
	(1,2)	(2,3)	(1,3)
Unknown items	7	9	19

Table 2.18 Frequency of errors for adjacent category pairs (1,2 and 2,3) and for remote category pairs (1,3) for unknown items

Friedman's two-way analysis of variance was calculated for the error frequencies of Table 2.18 $\chi^2_r = 5.45$, df = 2, $p<0.10$ ($\chi^2_{0.05} = 5.99$). It appears that most errors do occur for the remote category pair (1,3) although χ^2_r is not significant at $p<0.05$.

Although adopting output sequence1 or output sequence 3 is a successful strategy since for these sequences the two known categories are evaluated, in the present experiment the unknown category has the same set-relationship to both known categories for all correct diagrams (except for the alternative correct diagrams (see Fig.2.6) which were never correctly diagrammed). By simply assuming (without evaluating) that the unknown category (U) has the same set-relationship with the remote known category as it does with the evaluated adjacent known category will result in a correct diagram if subjects have adopted output sequences 1 or 3. Evaluating adjacent category pairs in output sequences 1 or 3 might be a sufficient strategy with the present experimental materials. Experiment 6 examines this possible failing of subjects to evaluate remote category pairs by using a wider range of stimulus items.

(ii) Diagramming sequence and errors for known items

For known items, the frequencies of the unknown category equivalents in positions 1, 2 and 3 for correct and incorrect diagrams are shown in Table 2.19 below.

		POSITION 1	2	3
Unknown items	Correct	79	5	42
	Incorrect	18	14	22

Table 2.19 Frequency of unknown category equivalents in positions 1, 2 and 3 for known items

Friedman's two-way analysis of variance by ranks was calculated for both correct and incorrect diagrams. For correct diagrams $\chi^2_r = 14.60$, df = 2, p<0.001. Nemenyi's a posteriori test for multiple comparison of means revealed that position 1 was used significantly more frequently than position 2 to diagram the unknown category equivalents. No other comparison was significant for correct diagrams. For incorrect diagrams $\chi^2_r = 3.8$, df = 2, n.s.

It is apparent for correct diagrams that the unknown category equivalents tend to be dealt more often at the beginning (position 1) rather than at the middle (position 2) or end (position 3) of subjects' diagramming sequences. For incorrect diagrams no significant positional differences were found. As with unknown items, subjects output sequences appears to be related to their success at generating correct diagrams.

Table 2.20 below gives the frequency of errors for adjacent and remote category pairs for known items.

	CATEGORY PAIR (1,2)	(2,3)	(1,3)
Known items	16	16	22

Table 2.20 Frequency of errors in adjacent category pairs (1,2 and 2,3) and remote category pairs (1,3) for known items

Friedman's two-way analysis of variance was calculated for the error frequencies in Table 2.20 $\chi^2_r = 1.85$, df = 2, n.s. There are no significant differences between error frequencies for adjacent and remote category pairs when subjects are diagramming known items. The finding that the unknown category equivalent tends to occupy position 1 in correct diagrams (Table 2.19) might be a function of the "syllogistic format"(eg the unknown category equivalents occur twice in a stimulus item). This is tested in the subsequent experiment (Experiment 5) where the three categories of each known stimulus item are merely listed (without quantifiers) and subjects are required to diagram the set-relationships among the three categories. By comparing performance on this task with performance on the known items in this experiment, it will be possible to evaluate the effects of the "syllogistic format" of presentation.

(iii) The direction of diagramming set-inclusions and error types for unknown items

Table 2.21 below gives the frequencies of the six error types (specified in the method section) for the adjacent (1,2 and 2,3) and remote (1,3) category pairs for unknown items.

		ERROR TYPE a	b	c	d	e	f	Σ
Unknown items	(1,2)	4	0	3	0	0	0	7
	(2,3)	8	0	1	0	0	0	9
	(1,3)	14	0	0	4	0	1	19
	Σ	26	0	4	4	0	1	Σ= 35

Table 2.21 Frequency of error types in adjacent and remote category pairs for unknown items

The majority of all errors made were of the a type (see Fig. 2.7) and these accounted for 74% of the total errors made. The type a error involves incorrectly diagramming a set-overlap instead of a set-inclusion, and these errors can occur whenever there is a subset/superset relationship to be diagrammed for any category pair. Set-inclusion represents the only unsymmetrical category pair relationship since subjects may diagram the superset before a subset or vice versa.

Every adjacent and remote set-inclusion category pair which was diagrammed was categorised as an "IN" or an "OUT" instance. "IN" refers to a category pair where the superset is diagrammed before the subset and "OUT" refers to a category pair where the subset is diagrammed before a superset. 58% of the total set-inclusions diagrammed were "IN" instances although a Wilcoxon test for two matched samples revealed no significant differences between subjects frequencies of "IN" and "OUT" instances.

The relative tendency for subjects to diagram superset before subset in their diagrammed set inclusions ("Percentage IN Strategy") was calculated for each subject as follows:

$$\frac{\text{frequency of IN instances}}{\text{frequency of IN and OUT instances}} \times 100$$

(Percentage OUT strategy is therefore (100 - % IN strategy)
Percentage IN strategy was correlated with type a errors on unknown items using Spearman's rank correlation coefficient. The correlation was not significant ($\rho = 0.21$, $N = 10$, n.s.). Subjects directional diagramming tendency for set-inclusions did not appear to be associated with type a errors.

(iv) <u>The direction of diagramming set-inclusions and error types for known items</u>

Table 2.22 gives the frequencies of the six error types (see Fig. 2.7) for the adjacent (1,2 and 2,3) and remote (1,3) category pairs for known items.

		ERROR TYPE a	b	c	d	e	f	Σ
Known items	(1,2)	10	0	4	0	1	1	16
	(2,3)	12	0	3	1	0	0	16
	(1,3)	12	3	2	4	0	1	22
	Σ	34	3	9	5	1	2	Σ= 54

Table 2.22 Frequency of error types in adjacent and remote category pairs for known items

The majority of all errors made were of the a type (see Fig. 2.7) and these accounted for 63% of the total errors made. 66% of the total set-inclusions diagrammed were "IN" instances (as defined previously). A Wilcoxon test for two matched samples, however, revealed no significant differences between subjects frequencies of "IN' and "OUT" instances. Subjects percentage IN strategy (as defined previously) was correlated with type a errors on known items and a significant correlation was detected ($\rho = 0.73$, $N = 10$, $p<0.05$). Subjects directional diagramming tendency for set-inclusion was significantly positively correlated with type a errors for known items. Some suggestions as to why this should occur is discussed in the conclusion of this experiment.

(v) Summary of results

(a) For unknown items, syllogistic type did not have a significant effect on diagramming time.

(b) For known items, syllogistic type has a significant effect on diagramming time. Subjects took significantly longer to diagram items of the syllogistic type I/I/4 than to diagram items of the syllogistic types E/E/1 or A/A/2.

(c) For unknown items, category relationship only had a significant effect on diagramming time within syllogistic type A/A/2. Stimulus items which contained a set-overlap (O) category relationship were diagrammed significantly slower than stimulus items which contained a set-exclusion (E) category relationship or a set-inclusion (S) category relationship.

(d) For known items, category relationship had a significant effect on diagramming time. Stimulus items which contained a set-exclusion (E) category relationship were diagrammed significantly faster than stimulus items which contained a set-overlap (O) category relationship or a set-inclusion (S) category relationship.

(e) For correctly diagrammed unknown items, the unknown categories were diagrammed significantly less frequently in position 2 than in position 1 or position 3. For incorrectly diagrammed unknown items, no significant positional differences were detected.

(f) For correctly diagrammed known items, the unknown category equivalents were diagrammed significantly less frequently in position 2 than in position 1. For incorrectly diagrammed known items, no significant positional differences were detected.

(g) For unknown items, a difference at $p<0.10$ was detected between error frequencies for adjacent (1,2; 2,3) and remote (1,3) category pairs. This can be accounted for by the greater frequency of errors for the remote category pair (1,3).

(h) For known items, there were no significant differences between error frequencies for adjacent (1,2; 2,3) and remote (1,3) category pairs.

(i) For unknown and known items, the majority of errors made were type a errors (i.e. incorrectly diagramming a set-overlap instead of a set-inclusion).

(j) Percentage IN strategy was significantly positively correlated with type a errors for known items but not for unknown items.

Discussion

The results have shown that there are clear performance differences between the manner in which subjects diagram unknown items (i.e. those which contain two known categories and one unknown category) and the manner in which subjects diagram known items (i.e. those which contain three known categories.)

In order to account for some of the present observations, it is assumed that subjects evaluate category pairs in stimulus items in order to determine the appropriate set-relationship to be diagrammed. With the present experimental materials, these category pairs can be conveniently partitioned into "between premise" and "within premise" category pairs. A "between premise" category pair are those two categories which occur in different premises in both unknown and known items. For example, in the unknown and equivalent known stimulus items shown below the between premise category pair is underlined.

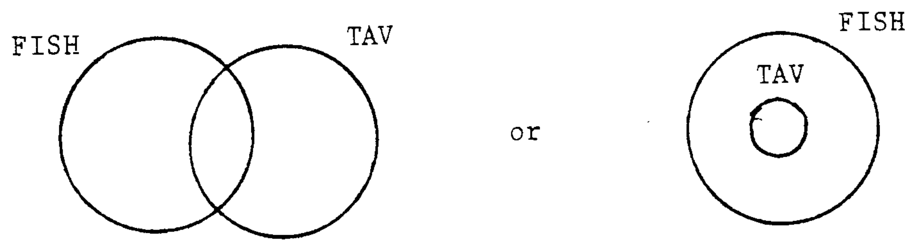
No LOZ are DOGS	No FISH are OAKS
No ANIMALS are LOZ	No TREES are FISH
Unknown item example	Known item example

Clearly the between premise category pairs always contain two known categories and are not linked with a quantifier. Evaluating the between premise category pair is generally necessary to arrive at the correct diagram. For example with the unknown stimulus item I/I/4/S, which could take the form:

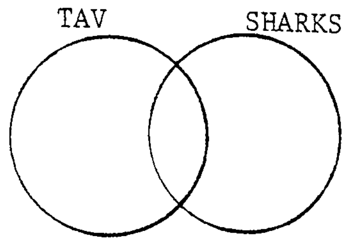
Some FISH are TAV

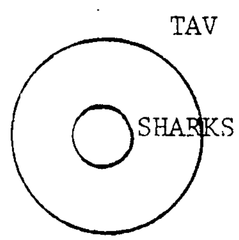
Some TAV are SHARKS

the category pair in the first premise might be correctly diagrammed as (see Fig. 2.4)

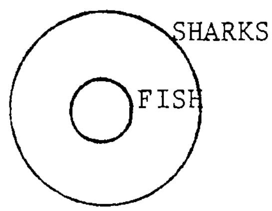


and the category pair in the second premise might be diagrammed as:

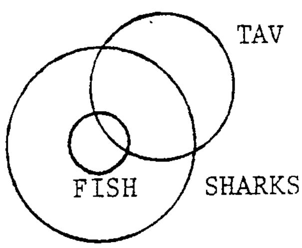




Since the relationship between the two known categories (the between premise category pair) is



then the unknown category (TAV) cannot simultaneously be a subset of fish and a superset of sharks. Consequently the only correct diagramming solution is:



The "within premise" category pairs are those which are linked with a quantifier. For the example above the two within premise category pairs are (FISH and TAV) and (TAV and SHARKS).

In evaluating the set-relationships of category pairs, an inference strategy is proposed in which subjects ask themselves a sequence of self-addressed questions. The proposed inference strategy is thought to operate for between premise category pairs in both known and unknown items since this evaluation is generally necessary to arrive at a correct diagramming solution. For within premise category pairs in known items (e.g. All DOGS are ANIMALS) subjects can either utilise the quantifier or their existing knowledge structure. If they choose the latter then they are dependent on the proposed inference strategy. For within premise category pairs in unknown items (e.g. All DOGS are LOZ) subjects are dependent on the quantifier at least in evaluating the first within premise category pair they choose to consider in a stimulus item. However in evaluating the second within premise category pair they choose to consider, they might utilise the quantifier or their existing knowledge structure, since at that point in time the unknown category has at least been partially understood.

The proposed inference strategy

The inference strategy consists of a sequence of self-addressed questions. The complete set of four self-addressed questions is given below. X and Y refer to the two categories of the category pair being evaluated.

(i) are some X, Y ?
(ii) are some Y, X ?
(iii) are all X, Y ?
(iv) are all Y, X ?

Subjects are assumed to make diagramming errors in two possible ways. Firstly, they can incorrectly answer their self-addressed questions. For example, the self-addressed question, "Are all birds flying things?"

is answered "yes" since the subjects search of semantic memory does not reveal an instance of, say, an ostrich. The well-known categories used in the present experiment were selected to be as unambiguously related as possible , and consequently it is assumed that this type of error has rarely occurred. The proposed inference strategy, therefore, does not include instances of subjects incorrectly answering their self-addressed questions.

The second type of error subjects can make is assumed to stem from subjects not asking the logically complete set of self-addressed questions to generate correct category pair solutions. These errors stem from incomplete processing and are only apparent under some circumstances since incomplete processing can in some cases lead to correct solutions. In the proposed inference strategy incomplete processing is assumed to result in diagramming errors.

Fig. 2.8 represents the proposed inference strategy. In this representation the symbol $\square$ denotes a self-addressed question stage. The letters X and Y refer to the category pairs in a self-addressed question. Since a subject may allocate either category to the X or Y position in a self-addressed question, either one of two alternative self-addressed questions may be asked at any of the three self-addressed question stages.

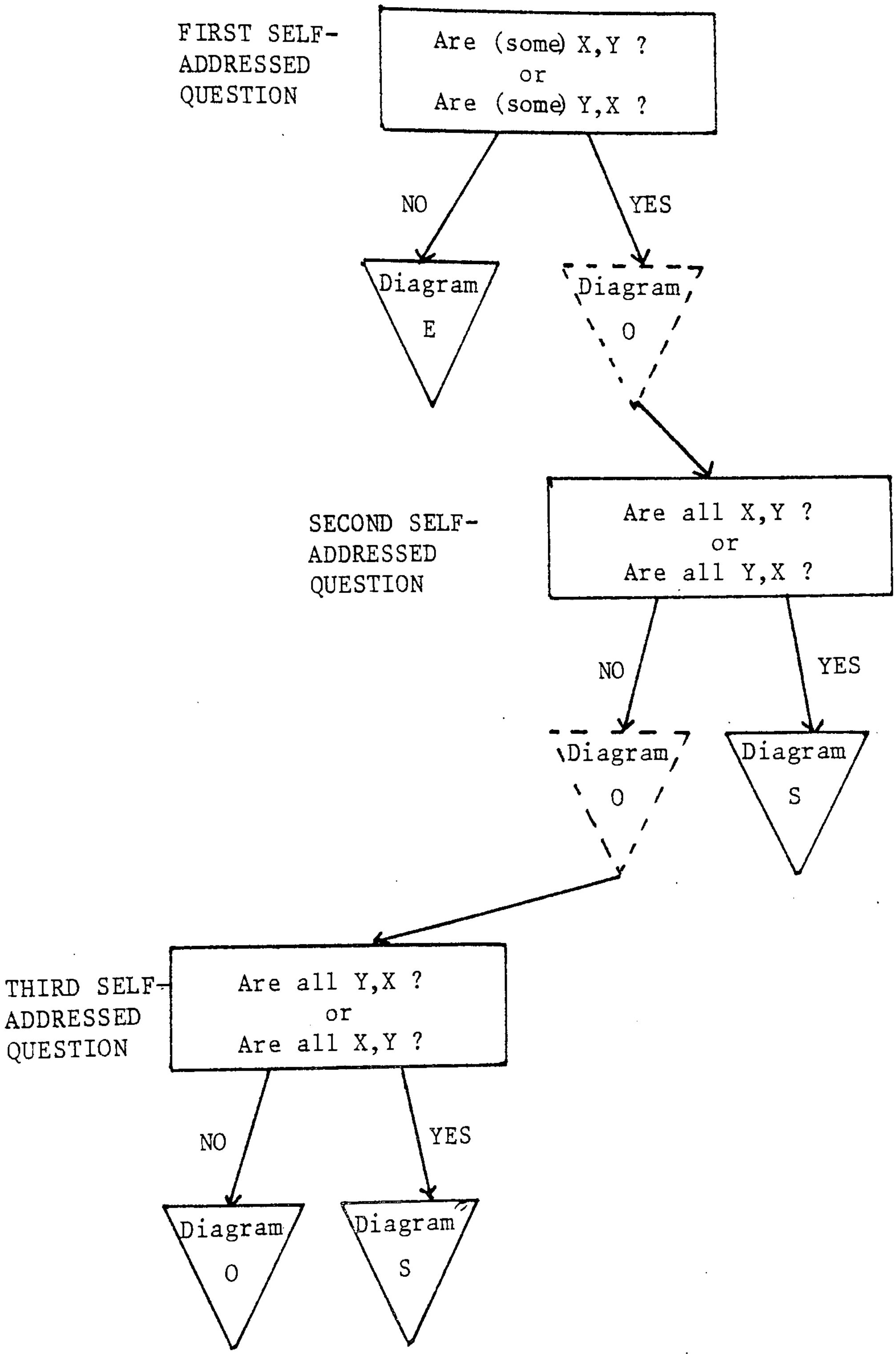
The symbol $\bigtriangledown$ denotes a correctly diagrammed category pair which follows the logically complete set of self-addressed questions. These correctly diagrammed category pairs can be specified as set-overlap (O), set-inclusion (S) or set-exclusion (E) and these letters are included in the symbol (e.g. Diagram O).

The symbol denotes a diagrammed category pair which does not follow the logically complete set of self-addressed questions. In order words the category pair has been logically prematurely diagrammed although the diagrammed category pair may be correct or incorrect. The set-relationship of the diagrammed category pair is specified as set-overlap (O), set-inclusion (S) or set-exclusion (E) and these letters are included in the symbol, (e.g Diagram O).

It can be seen from Fig. 2.8 that the first self-addressed question "are (some) X,Y ?" has the quantifier "some" bracketed. This is because at this stage, evaluation of the category pair may be merely a "check" to determine if there is any overlap between the categories X and Y (as suggested in stage 1 of Meyers, 1970, model) or even a simple direct access recognition process in semantic memory (as suggested by Wickelgren, 1979). However, in the present proposed inference strategy subjects may choose to ask the quantified self-addressed question "are some X,Y ?" rather than the unquantified "are X,Y ?". Whether subjects are merely checking for any feature overlap ("are X,Y ?") or searching through any overlap discovered ("are some X,Y ?") does not alter the subsequent proposed stages in the inference strategy which are briefly described below.

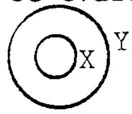
Stage 1

If subjects correctly answer "no" to the first self-addressed question (i.e. "are (some) X,Y ?" or "are (some Y,X ?") then they correctly



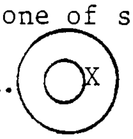
KEY

X ≡ One category in a category pair
Y ≡ One category in a category pair
E ≡ Set exclusion
O ≡ Set overlap
S ≡ Set inclusion
□ ≡ Self-addressed question stage
▽ ≡ Diagrammed category pair following logically complete set of questions
⛛ ≡ Diagrammed category pair logically prematurely diagrammed

Fig. 2.8 Proposed inference strategy for a category pair diagram a set-exclusion for the category pair in question. If subjects correctly answer "yes" to the first self-addressed question then it is suggested that they might prematurely diagram a set-overlap for the category pair in question. This would be correct if the set-relationship of the category pair was a set-overlap and incorrect if the set-relationship of the category pair was a set-inclusion. This premature diagramming of a set-overlap can occur in two ways, when the set-relationship of the category pair in question is one of set-inclusion. Firstly, if the set-inclusion of the category pair to-be-evaluated is such that X is the subset and Y is a superset (.ie. 

then subjects may choose either "are (some) X,Y ?" or "are (some) Y,X ?" as their first self-addressed question. Subjects who choose "are (some) Y,X ?" as their first self-addressed question and who correctly answer "yes" might incorrectly assume that "some X are Y" rather than "all X are Y" and consequently incorrectly diagram a set-overlap. This would be an error of illogical conversion (i.e. symmetry between sets is incorrectly deduced) and these types of errors are common in reasoning tasks (Johnson-Laird 1970; Wason and Johnson-Laird, 1972). The second way in which the premature diagramming of a set-overlap may occur is when subjects choose "are (some) X, Y ?" as their first self-addressed question. Subjects who answer "yes" to this question are only correct if they are taking "some" to include "all". (which is, of course, the case in mathematical logic). However, subjects may not pose the quantified question "are some X,Y?" but rather the unquantified question "are X,Y ?". The overlap of features discovered may predispose subjects to prematurely diagram a set-overlap, without determining whether X is a subset of Y (this would also be the case for "are Y,X ?").

Stage 2

If subjects have not correctly diagrammed a set-exclusion or prematurely diagrammed a set-overlap after the first self-addressed question it is proposed that the second self-addressed question is asked. At this stage of processing the sequence of categories in the self-addressed question is critical. If the set-relationship of the to-be-evaluated category pair is one of set-inclusion with X as the subset and Y as the superset (i.e. 

Y) and subjects choose to ask "are all X,Y ?" then they correctly answer "yes" and correctly diagram a set-inclusion. However, if subjects choose to ask "are all Y, X ?" and correctly answer "no" then some subjects might diagram a set-overlap since at Stage 1 their previous self-addressed question (i.e. "are (some) X,Y ?" or "are (some) Y,X ?") had been correctly answered "yes".

Stage 3

Those subjects who have posed the second self-addressed question with the superset as the first category, must reverse the order of categories in their next self-addressed question. If they correctly answer "yes" to the third self-addressed question then a set-inclusion is correctly diagrammed. If the correct answer is "no" at this stage of processing then a set-overlap is correctly diagrammed.

In order to illustrate more explicitly how the proposed inference strategy operates when to-be-evaluated category pairs have an O, E and S set-relationship, Fig. 2.9 includes category examples. Predicted error types (see Fig. 2.7) are included at appropriate points in the diagrams of Fig. 2.9.

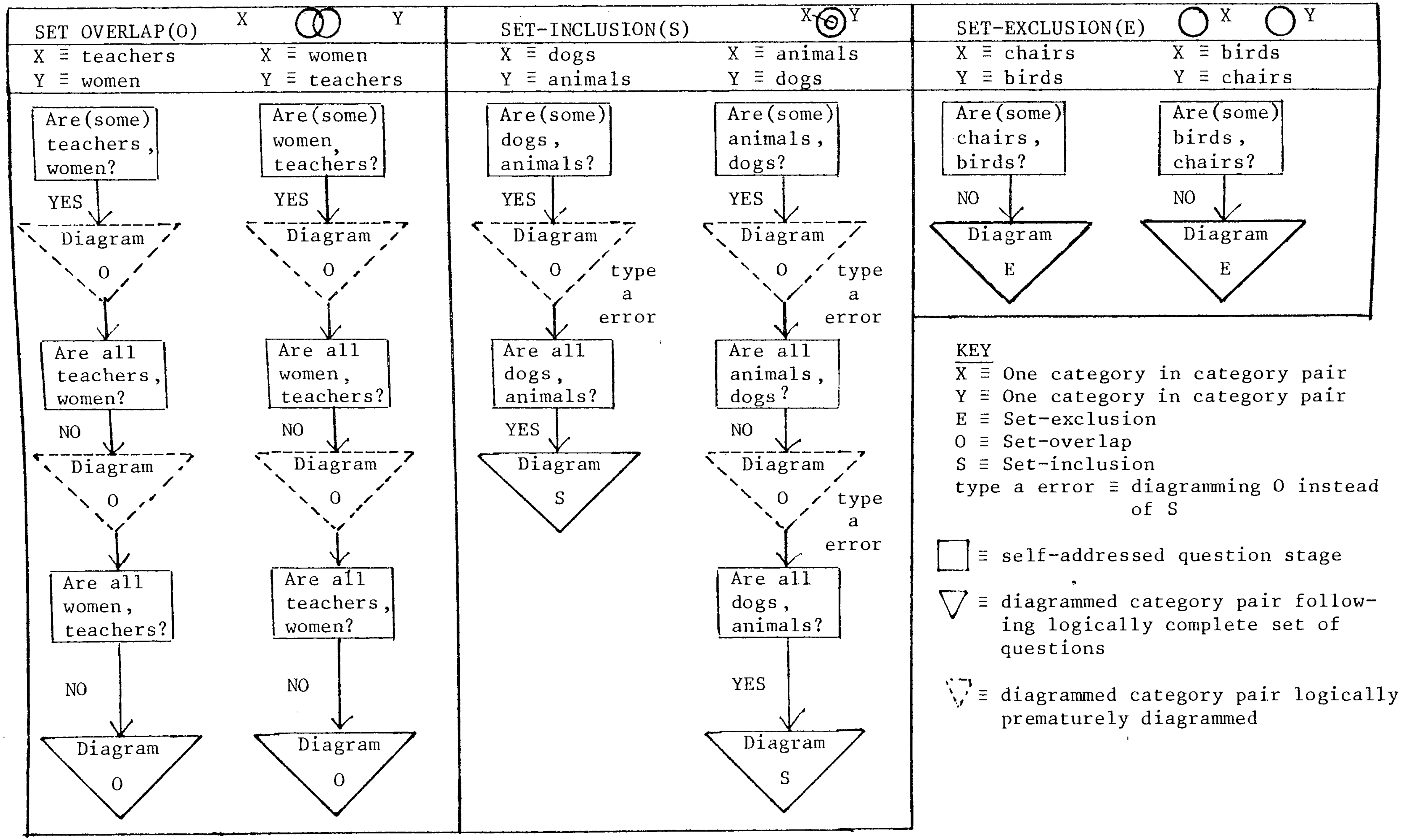


Fig. 2.9 Proposed inference strategy and predicted errors in evaluating category pairs

It can be seen from Fig. 2.9 that the proposed inference strategy only predicts type a errors (i.e. diagramming a set-overlap instead of a set set-inclusion). The majority of errors made on both known and unknown items were of this type (Table 2.21 and Table 2.22). For those subjects who tend to consider supersets before subsets (as inferred from their diagramming sequences) it can be seen from Fig. 2.9 that a correct diagramming solution for an inclusion category pair requires subjects to reverse the categories in their self-addressed "all" question and consider the subset before the superset. Consequently it is suggested that subjects who tend to diagram supersets before subsets (Percentage IN Strategy) are more likely to make type a errors since more processing is required (and incomplete processing more likely) under these conditions (see Fig. 2.9). However, a significant positive correlation between percentage IN strategy and type a errors is only found for known items but not for unknown items.

For known items, the set-relationship of the between premise category pairs (i.e. the treatment "category relationship in known items") has a significant effect on diagramming times. It can be seen from Table 2.16 that for diagramming time S > E and O > E. This is in accord with the proposed inference strategy (Fig. 2.9) where it can be seen that set-exclusion category pairs can be quickly evaluated. An assumption in the proposed inference strategy at this stage (in common with Meyer's, 1970, model) is that there are completely non-intersecting sets. The problem is that even apparently unrelated category pairs might share some features. For example, the categories "CHAIRS" and "WINDOWS" although apparently non-intersecting sets can both be considered members of the class of "wooden things" and may have common features (like sometimes being found in houses).

The "syllogistic type" factor (see Table 2.16) is a less direct measure of relevant task variables although known stimulus items which required set-exclusion diagrams for two category pairs (i.e. syllogistic type E/E/1) resulted in faster diagramming times than known stimulus items which required set-overlap diagrams for two category pairs (i.e. syllogistic type I/I/4). This is in accord with the proposed inference strategy.

Although the proposed inference strategy can account for the data fairly satisfactorily for known items, for unknown items the situation is more complex. Although type a errors are the dominant error type for unknown items, there is not a significant correlation between percentage IN strategy and type a errors. Further, the effects of the factor category relationship of the two known categories are only apparent on diagramming time within the syllogistic type A/A/2.

It is suggested that when subjects are diagramming unknown items they tend not to completely evaluate the set-relationship of the unknown category to both known categories. Simply by assuming that the unknown category has the same set-relationship with the remote known category as it does with the adjacent evaluated known category will result in a correct diagram if subjects have adopted output sequence 1 (UKK) or output sequence 3 (KKU) (see Table 2.17) since in the present experimental materials the unknown category (U) has the same set relationship to both known (K) categories. The finding that output sequence 2 (KUK) occurs more frequently when subjects are making errors (see Table 2.17) and that these errors occur more frequently for the remote category pair (1,3) (see Table 2.18) supports this contention.

In a subsequent experiment (Experiment 6) it is hypothesised that for stimulus items in which the unknown category has the same set-relationship to both of the known categories less errors will be made compared to stimulus items in which the unknown category has a different set-relationship to each of the known categories. In this way, it should be possible to test whether the identified successful output sequences are task specific strategic responses to the particular experimental materials used in this experiment or reflect a general failing of subjects to evaluate remote category pairs with material of this type.

Conclusions

(i) The diagramming relationships methodology appears to be a useful way in which to investigate the incorporation of new information into an individual's existing cognitive structure.

(ii) An inference strategy has been proposed which can successfully account for some of the present observations.

(iii) Although a set-theoretic representation of semantic memory has served as a useful description, the results may well be reflecting processing strategies rather than supporting this view of the underlying structure of knowledge.

2.8 EXPERIMENT 5 : DIAGRAMMING THE RELATIONSHIPS BETWEEN THREE KNOWN CATEGORIES PRESENTED IN A LIST FORMAT

Introduction

It has been suggested in Experiment 4 that when subjects are diagramming three known categories presented in a syllogistic format, performance with respect to diagramming times and errors is consistent with the suggestion that subjects utilise an inference strategy comprising a sequence of self-addressed questions. Quantified statements, are, however, not necessary to the task of diagramming relationships when all three categories of a stimulus item are already known to subjects. For example, the stimulus item:

All DOGS are ANIMALS

All CATS are ANIMALS

could be presented as a list:

DOGS

ANIMALS

CATS

and subjects can still diagram the relationships among the three categories. The effects of the syllogistic format of presentation used for the known items of Experiment 4 are assessed in this experiment by presenting sets of three categories in a list rather than in a pair of quantified premises. In comparing subjects' performance between the two presentation formats, it will be possible to assess whether the proposed inference strategy suggested to operate in the syllogistic format is consistent with performance on stimulus items presented in the list format.

Method

Design and materials: The test material consisting of 18 stimulus items contained the same categories as the 18 known items of Experiment 4. The three categories were listed in each stimulus item rather than being structured into a syllogistic format as for the known items of Experiment 4. The order of the three listed categories for each stimulus item in the present experiment was the same order, in which the categories appeared in the known stimulus items of Experiment 4. For example, for the known stimulus item:

All CABBAGES are PLANTS

All VEGETABLES are PLANTS

the equivalent stimulus item in the "list format" would be:

CABBAGES

PLANTS

VEGETABLES

Procedure

The same experimental procedure was used as in Experiment 4. The instructions to subjects were adapted to suit the list rather than the syllogistic format, but were identical in all other respects to the instructions relating to the known items of Experiment 4. A copy of the verbatim instructions is given in Appendix 6(e).

Subjects: Ten students from the Faculty of Social Sciences & Humanities, University of Aston, were randomly selected to serve as experimental subjects. They had not participated in Experiment 4.

Dependent variables

(i) Diagramming time for each stimulus item

(ii) Number and type of errors (see Fig. 2.7) for each item

(iii) Output sequence of categories for each item.

Results

The results are dealt with in two sections. In the first section diagramming time is examined and in the second section subjects strategies and diagramming errors are examined.

Diagramming time

(i) Diagramming time for items in the list format

In order to compare the list format of the present experiment with the syllogistic format used for known items in Experiment 4, subjects mean diagramming times on all stimulus items were tested for a difference ($t = 2.90$, $df = 8$, $p<0.05$). The list format stimulus items were diagrammed significantly faster than the syllogistic format items.

A randomised block factorial analysis of variance (RBF 3x3; Kirk, 1968) was calculated for subjects diagramming times on list format stimulus items using the two factors (i.e. syllogistic type and category relationship) which had been applied to the equivalent analysis for syllogistic format stimulus items (Experiment 4). The analysis of variance summary table is given in Appendix 4 (Table a). Blocks (subjects) had a significant effect on diagramming times ($F = 15.98$, $df = 9,72$, $p<0.01$). The syllogistic type x category relationship interaction was significant and consequently there is little interest in the main effects. A simple main effects analysis of variance was therefore calculated and the summary table is given in Appendix 4 (Table b). This analysis, followed by a multiple comparison of means procedure (Tukey's HSD test) revealed a number of significant contrasts between item types (identified by the notation used for syllogistic format item types in Experiment 4 (see Fig. 2.6) and given in Appendix 4, table c).

For known items in Experiment 4 both factors (i.e. syllogistic type and category relationship) were significant main effects on diagramming time (see Table 2.16, Experiment 4). In the list format there was a significant interaction between both factors and consequently the pattern of results for diagramming times differs between the two presentation formats.

However, a correlation between subjects' mean diagramming times for the nine item types in the list and syllogistic formats was significant ($r = 0.83$, $df = 7$, $p < 0.01$). This significant positive correlation implies that the relative speed of diagramming item types is consistent to some extent between the two presentation formats.

(ii) Diagramming time and errors

A Spearman's rho correlation coefficient was calculated between subjects' mean diagramming time and errors ($\rho = 0.07$, $N = 10$, n.s.). This was not significant and therefore subjects were not trading diagramming speed for errors.

Subject strategy and diagramming errors

(i) Diagramming sequence and errors for items in the list format

For each diagram subjects draw, each category can be drawn first, second or third (referred to as positions 1, 2 or 3). The frequency of occurrence of those categories which were the unknown category equivalents in the known items of Experiment 4, in positions 1, 2 and 3 for correct and incorrect diagrams in the list format is shown in Table 2.23.

		POSITION 1	2	3
List Format	Correct	48	16	68
	Incorrect	21	15	12

Table 2.23 Frequency of unknown category equivalents in positions 1, 2 and 3 for the list format

Friedman's two-way analysis of variance by ranks was calculated for correct and incorrect diagrams. For correct items $\chi^2_r = 8.52$, df = 2, $p<0.02$. Nemenyi's a posteriori test for multiple comparison of means revealed that position 3 was used significantly more frequently than position 2 to diagram the unknown category equivalent. No other comparison was significant for correct items. For incorrect items $\chi^2_r = 1.55$, df = 2, n.s.

It is apparent that when subjects are correctly diagramming they tend to diagram the unknown category equivalents more frequently in position 3 compared to position 2. When the same category is presented in the syllogistic format it tends to be diagrammed more often in position 1 than in position 2 (see Table 2.19, Experiment 4).

Adjacent category pairs are those diagrammed first and second (1,2) or second and third (2,3) in subjects output sequences. Remote category pairs are those that are diagrammed first and third (1,3) in subjects output sequences. Table 2.24 gives the frequency of errors for adjacent (1,2 and 2,3) and remote (1,3) category pair for items in the list format.

	CATEGORY PAIR (1,2)	(2,3)	(1,3)
List format	16	26	19

Table 2.24 Frequency of errors in adjacent category pairs (1,2 and 2,3) and remote category pairs (1,3) for items in the list format

Friedman's two-way analysis of variance was calculated for the error frequencies in Table 2.24. As with the items in the syllogistic format of Experiment 4 (see Table 2.20) no significant differences between adjacent and remote category pairs were detected with items in the list format.

(ii) <u>The direction of diagramming set-inclusions and error types for items in the list format.</u>

Table 2.25 gives the frequencies of the six error types (see Fig. 2.7, Experiment 4) for the adjacent (1,2 and 2,3) and remote (1,3) category pairs for unknown items.

		ERROR TYPE a	b	c	d	e	f	Σ
List Format	(1,2)	11	0	5	0	0	0	16
	(2,3)	23	0	2	1	0	0	26
	(1,3)	13	1	5	0	0	0	19
	Σ	47	1	12	1	0	0	Σ= 61

Table 2.25 Frequency of error types in adjacent and remote category pairs for items in the list format

The majority of all errors made were of the a type (see Fig. 2.7 Experiment 4) and these accounted for 77% of the total errors made.

In order to compare the total number of errors made in the list format and syllogistic format, a Mann-Whitney U test was calculated ($U = 44.5$, $N = 10$, n.s.).

In order to compare the number of type a errors made in the list format and syllogistic format, a Mann-Whitney U test was calculated ($U = 39.5$, $N = 10$, n.s.).

It is apparent that there are no significant differences between the list format and syllogistic format for either total errors or type a errors.

Every adjacent and remote set-inclusion category pair which was diagrammed was categorised as an "IN" or an "OUT" instance. "IN" refers to a category pair where the superset is diagrammed before the subset and "OUT" refers to a category pair where the subset is diagrammed before a superset. The relative tendency for subjects to diagram supersets before subsets in their diagrammed set-inclusions is referred to as "Percentage IN Strategy" as in Experiment 4 and was calculated for each subject as follows:

$$\frac{\text{frequency of IN instances} \times 100}{\text{frequency of IN and OUT instances}}$$

A Spearman's rho coefficient of correlation was calculated between Percentage IN Strategy and type a errors (ρ = 0.18, N = 10, n.s.). Unlike the syllogistic format of Experiment 4, it is apparent that there is not a significant positive correlation between Percentage IN Strategy and type a errors. With items in the list format, subjects directional diagramming tendency for set-inclusions was not associated with type a errors.

Discussion and conclusions

The results have shown that in diagramming identical sets of three known categories performance differs depending on the format in which the categories are presented. The pattern of diagramming time results differs between the syllogistic format and list format although there is a significant positive correlation between mean diagramming times for the nine item types in the list and syllogistic format (r = 0.83, df = 7, p<0.01). The list format stimulus items were diagrammed significantly faster than the syllogistic format items ($t = 2.90$, $df = 8$, $p<0.05$). It appears that subjects utilise premise information even when it is not necessary to the diagramming task.

It has been suggested in the previous experiment that inference strategies are involved when subjects are evaluating stimulus items which consist of quantified premises. In the syllogistic format when subjects are correctly diagramming, the unknown category equivalents in known items tend to be diagrammed more frequently in the first than in the second position (Table 2.19, Experiment 4). In contrast when subjects are correctly diagramming in the list format, the unknown category equivalents tend to be diagrammed more frequently in the third than in the second position (Table 2.23). Output sequence is considered to reflect some aspects of search and retrieval from semantic memory and consequently it is suggested that different processes underly performance in the diagramming task under the list or syllogistic presentation. The results of the present experiment (Table 2.25) show that the majority of errors made are type a errors (i.e. incorrectly diagramming a set-overlap instead of a set-inclusion) but unlike items in the syllogistic format there is no significant correlation between subjects Percentage IN Strategy and type a errors. This implies that the particular inference strategy postulated for evaluating set-inclusion category pairs may not be able to account for type a errors which occur with items in the list format. Other strategies may be operating, presumably relating to the search and retrieval of information from semantic memory but these are not specifiable without further investigation.

Performance on the diagramming task depends on a complex interaction between presentation mode, the structure of prior knowledge, and the processing strategies subjects utilise.

2.9 EXPERIMENT 6 : DIAGRAMMING RELATIONSHIPS - EXPERIMENTER IMPOSED STRATEGIES AND PERFORMANCE

Introduction

Experiment 4 of this unit has suggested a number of issues which are examined in the present experiment. It has been suggested previously that when subjects were diagramming unknown items (i.e. two known categories (K) and one unknown category (U) they were not evaluating the set-relationships of all three categories in a stimulus item.

Three instructional conditions are utilised in the present experiment:

CONDITION 1 : Instructing subjects to diagram supersets before subsets in any to-be-diagrammed set-inclusions they encounter in stimulus items.

CONDITION 2 : Instructing subjects to diagram subsets before supersets in any to-be-diagrammed set-inclusions they encounter in stimulus items.

CONDITION 3 : Instructing subjects to diagram subsets and supersets in any order they choose in any to-be-diagrammed set-inclusions they encounter in stimulus items.

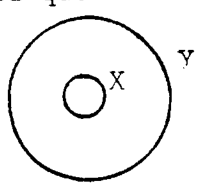
In Conditions 1 and 2 constraints are imposed on the sequence in which subjects can diagram the three circles representing the three categories of a stimulus item. It is suggested that imposing constraints on subjects diagramming sequences will induce subjects to evaluate the set-relationships among categories more completely when the experimenter-imposed output sequence does not match the subjects' choice of output sequence. In Condition 3, where subjects are free to choose their output sequence, evaluation of categories might be less complete.

Errors in the diagramming task are considered to stem from incomplete evaluation and consequently, less diagramming errors should be made in the constrained conditions (1 and 2) compared to the unconstrained condition (3).

In Experiment 4 it was impossible to ascertain whether subjects were failing to evaluate remote category pairs when they were correctly diagramming. This was the case because of two factors. Firstly, with the experimental materials used in Experiment 4, the unknown category always had the same set-relationship to both known categories in all stimulus items. Secondly, subjects almost always adopted output sequence 1 (UKK) or output sequence 3 (KKU) (see Table 2.17, Experiment 4), when they were successfully diagramming. When subjects adopted these output sequences in Experiment 4 they might have been successfully diagramming relationships by merely assuming (without evaluating) that the unknown category (U) had the same set-relationship with the remote known category as it had with the adjacent evaluated category. (A remote category pair refers to that pair of categories diagrammed in the first and third (1, 3) positions and an adjacent category pair refers to those pairs of categories diagrammed in the first and second (1, 2) or second and third (2, 3) positions in subjects diagramming sequences).

In order to examine whether subjects generally tend not to evaluate remote category pairs, a wider range of stimulus item types is used in the present experiment. Half of the item types were designed such that the unknown category had the same set-relationship to both known categories (referred to as "balanced" items) and half were designed such that the unknown category had a different set-relationship to both known categories (referred to as "unbalanced" items). If, as has been suggested in Experiment 4, subjects tend not to evaluate the unknown category with the remote known category then less errors should occur in diagramming balanced items than in diagramming unbalanced items in the unconstrained condition 3. In the constrained conditions (1 and 2), this difference may not be apparent since subjects may evaluate the set-relationships among categories more completely.

If subjects are induced to evaluate the set-relationships among the three categories more completely in the constrained conditions (1 and 2), it is further suggested that they will become more dependent on an inference strategy of the type outlined in the discussion of Experiment 4. The proposed inference strategy predicts a directional effect on the frequency of type a errors. These errors involve incorrectly diagramming a set-overlap instead of a set-inclusion and were the most common error type committed in Experiment 4. It can be seen from Fig. 2.8 (Experiment 4) that the likelihood of type a errors depends on the order in which subjects allocate the subset and superset components of to-be-evaluated set-inclusion category pairs in their self-addressed questions. Given that the to-be-evaluated set-inclusion is



then subjects who choose the subset category as their first term in their second self-addressed question (i.e. "are all X, Y ?") are less likely to make type a errors than subjects who choose the superset category as their first term in their second self-addressed question (i.e. "are all Y, X ?").

Since the majority of errors committed in the diagramming relationships task have been shown to be type a errors, the possibility arises that more successful diagramming will result if subjects are instructed to diagram subsets before supersets for any set-inclusion they encounter. This directional constraint is anticipated to induce subjects to consider the subset component as the first term in the self-addressed questions. Consequently less type a errors may be made in condition 2 compared with conditions 1 or 3.

The proposed inference strategy (see Fig 2.8 Experiment 4) also predicts a differential effect on diagramming times for the evaluation of category pairs with different set-relationships. If subjects are more dependent on an inference strategy in the constrained conditions (1 and 2) then this should be reflected in differential effects on diagramming times for the set-relationships of known category pairs. If subjects rely less on the proposed inference strategy in condition 3 then different set-relationships of known categories may not be associated with differential diagramming times in this condition.

The present experiment has an additional feature which was not incorporated in Experiment 4. After diagramming each stimulus item, subjects were required to suggest a category name for the unknown category. Subjects' speed and accuracy at this "unknown category naming" task were recorded. Consequently, if more complete evaluation of categories occurs in constrained conditions (1 and 2) than in unconstrained condition 3, then these measures of comprehension of the unknown category might reflect this.

Method

Design and materials: The test material of 24 items, each consisting of pairs of quantified premises were generated as shown in Fig. 2.10. As with the stimulus items of Experiment 4, an item type can be identified by specifying the "mood" of the premise pair, the "figure" in which the premises are cast, and the set-relationship of the two known categories in an item. All items were cast in Figure 2. (i.e. $\begin{matrix} K - U \\ K - U \end{matrix}$). In Fig. 2.10 the two known categories (K) for a correct diagram are represented by "light" circles and the one unknown category (U) for a correct diagram is represented by a "heavy" circle. Unknown categories in stimulus items were CVC's. In Fig. 2.10 a blank cell signifies that no correct diagram is possible, bearing in mind that in the diagramming relationships methodology, set identity is not allowed (i.e. there are always three circles in a correct diagram) and that the stronger quantifier "all" is always used in a premise wherever possible in preference to the quantifier "some". The two set-inclusion relationships of the two known categories are distinguished by where the subset component of the set-inclusion occurs. For the set-relationship of the two known categories designated as S in Fig. 2.10 the subset occurs in the first premise. For the set-relationship of the two known categories designated as H in Fig. 2.10 the subset occurs in the second premise. As with the stimulus items of Experiment 4, syllogistic type can be identified by combining "mood" and "figure". Seven syllogistic types were selected and these are shown in Fig. 2.10.

By combining syllogistic types with set-relationship of the two known category pairs, it can be seen from Fig. 2.10 that there are 24 item types. For each item type, one stimulus item was generated to give 24 stimulus items in all each containing two known categories and one unknown category. The known categories were selected to be as unambiguously related as possible.

It can be seen from Fig. 2.10 that a number of item types have alternative correct diagramming solutions. These alternative solutions sometimes occur when a "some" premise is included as one of the premise pairs in a stimulus item and stem from two possible solutions for a "some" premise (i.e. set-overlap or set-inclusion). These alternative correct solutions are shown in Fig. 2.10.

Balanced item types are those in which the unknown category has the same set-relationship to both known categories and these are labelled in Fig. 2.10. Unbalanced item types are those in which the unknown category has a different set-relationship to both known categories and these are also labelled in Fig. 2.10.

Each of the 24 stimulus items was printed on a card and the presentation order randomised for each subject. All items were presented to all subjects.

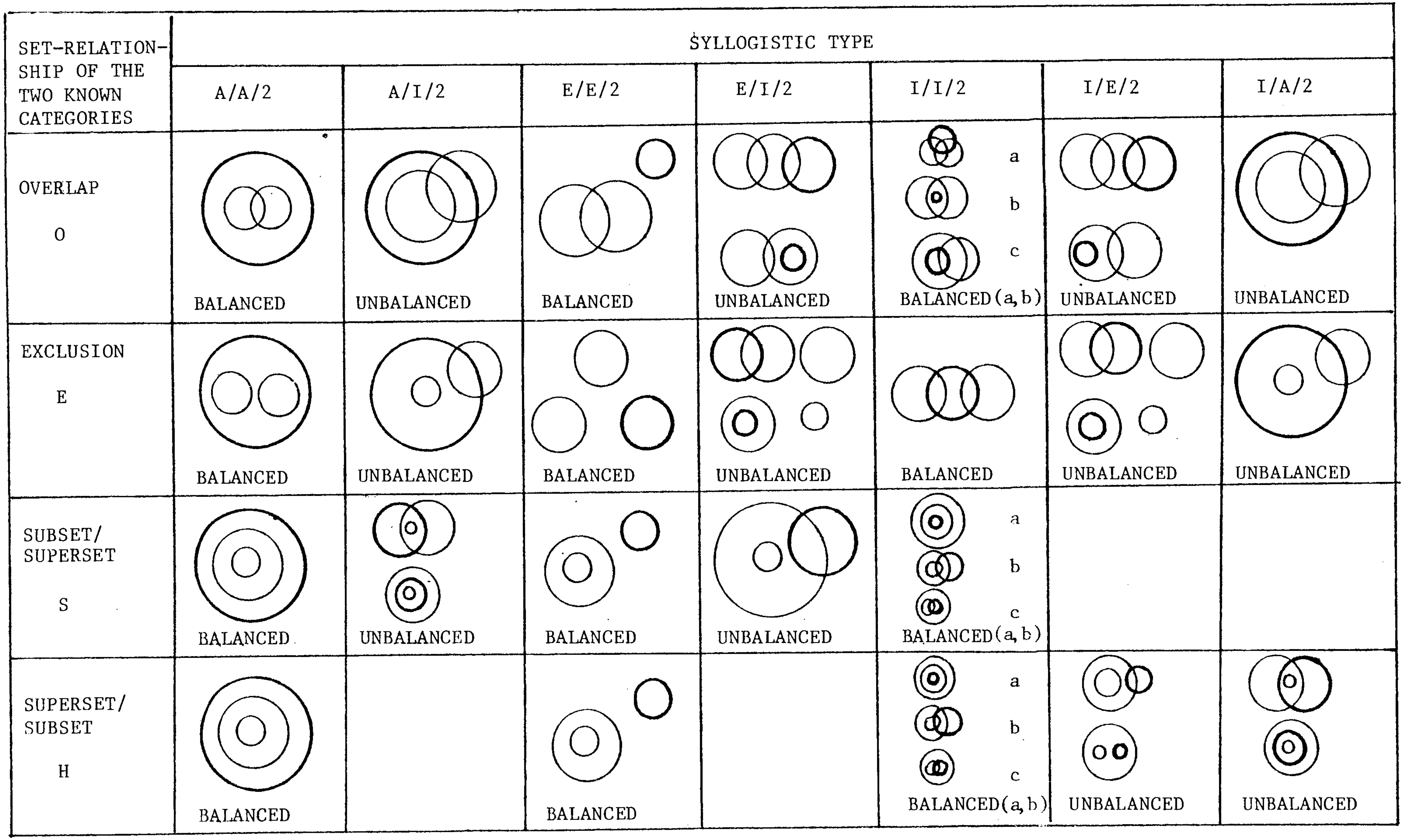


Fig. 2.10 Possible correct diagrams for the twenty-four item types

KEY (to Fig. 2.10)

O ≡ set-overlap known category relationship

E ≡ set-exclusion known category relationship

S ≡ set-inclusion known category relationship (subset in first premise)

H ≡ set-inclusion known category relationship (superset in first premise)

(O)≡ known category (light circle)

(O)≡ unknown category (heavy circle)

A ≡ "All" premise

E ≡ "No" premise

I ≡ "Some"premise

2 ≡ Syllogistic Figure 2 (i.e. K-U) (K-U)

Procedure

The subjects were tested individually. On entering the test room each subject was asked to read carefully a set of instructions about the diagramming relationships task. Subjects were asked "to use your knowledge of the groups you know and the information in the item to draw the correct relationship". The same instructions were employed as in Experiment 4, but all subjects received additional instruction on subsets and supersets and how they should be dealt with in category inclusion items. Subjects in condition 1 were instructed to diagram supersets before subsets in items which contained category inclusion relationships. Subjects in condition 2 were instructed to diagram subsets before supersets in items which contained category inclusion relationships. Subjects in condition 3 were told they could diagram subsets and supersets in any order for items which contained category inclusion relationships.

The order of presentation of items was randomised for each subject. Each item was printed on a card and the experimenter presented each item in turn to a subject. The subject's task was to draw the correct diagram on the paper provided. Subjects were instructed to work as quickly as possible without making any errors. The experimenter timed the subject for each diagram drawn. Subjects were instructed to cross out any incorrectly drawn item (if they spotted a mistake) and to redraw what they assumed to be the correct one. When they were satisfied with their diagram, subjects were instructed to say "right" as a signal to the experimenter to stop the stopwatch. While the experimenter noted the diagramming time for each item, subjects were instructed to mark each of the three circles in the diagram they had just drawn with a 1, 2 or 3 to show the order in which they were diagrammed. Subjects were also required to label each of the three circles in the diagram with the category name associated with it. Before proceeding to the next item subjects were asked to generate an example of what the unknown category might be in their diagram. The time taken to generate an example was noted by the experimenter.

All subjects were given five practice items to familiarise them with the experimental procedure during which any questions arising were answered by the experimenter. It was made clear that there was always at least one correct solution for each item, and the necessity of using theknowledge of the relationship between the two known categories in each item was stressed. A copy of the verbatim instructions is given in Appendix 6(f).

Subjects: Sixty-nine students from the Faculty of Social Sciences & Humanities, University of Aston, were randomly selected and allocated to the three experimental conditions. Four were rejected because they had failed to diagram subset and superset components in the correct sequence for all items in conditions 1 and 2. This left 21 subjects in conditions 1 and 2. Two subjects were randomly deleted from condition 3 to give a balanced design with 21 subjects in each condition (N = 63). Since only two deletions were required this procedure is acceptable (Lee, 1975).

Results

The results are dealt with in four main sections. These sections are diagramming times, diagramming errors, unknown category naming times and unknown category naming errors. A summary of results is included at the end of the section.

Diagramming time

(i) Mean diagramming times for correctly diagrammed stimulus items between experimental conditions 1, 2 and 3

Means and standard deviations in each experimental condition for subjects' mean diagramming time for correct itemsare given in Table 2.26 below.

	$\overline{X}$ (secs)	S.D.
CONDITION 1	13.84	6.57
CONDITION 2	13.09	5.66
CONDITION 3	14.42	6.30

Table 2.26 Means and standard deviations for subjects' mean diagramming time for correct items in the three experimental conditions

A one-way analysis of variance (CR-3 design, Kirk, 1968) was calculated for subjects' mean diagramming times for correct items in the three experimental conditions. The analysis of variance summary table is given in Apprendix 5 (table a). For this analysis $F = 0.23$, df = 2,62 n.s. There are no significant differences between the three experimental conditions on this measure of performance.

(ii) Mean diagramming times for correct items within each of the experimental conditions

It can be seen from Fig. 2.10 that the set-relationship of the two known categories in each stimulus item can be either set-overlap (O), set-exclusion (E) or set-inclusion (S or H). The S category relationship has the subset component of the set-inclusion included in the first premise of a stimulus item. In the H category relationship, the superset component of the set-inclusion is included in the first premise of a stimulus item. Means and standard deviations of diagramming times for the four known category relationships under the three experimental conditions are given in Appendix 5 (Table b).

A randomised block analysis of variance (RB-4 design; Kirk, 1968) was calculated for mean diagramming times on O, E, S and H correctly diagrammed stimulus items for each of the experimental conditions. These three analysis of variance summary tables are given in Appendix 5 (Tables c, d end e). Subsequent Tukey's multiple comparison of means were calculated where appropriate and the results are summarised in Table 2.27 below.

	F	p	TUKEY'S MCOM SIGNIFICANT CONTRASTS	p
CONDITION 1 (supersets before subsets)	5.41 (df = 3,54)	<0.01	O > E O > S O > H	<0.01 <0.01 <0.01
CONDITION 2 (subsets before supersets)	5.70 (df = 3,54)	<0.01	O > E O > H	<0.05 <0.05
CONDITION 3 (subjects' choice)	2.47 (df = 3,48)	n.s.		

Table 2.27 RB-4 Analyses of variance and significant contrasts for the category relationship of known items (i.e. O, E, S of H) on subjects' mean correct diagramming times within each experimental condition

It can be seen from Table c (Appendix 5) that within condition 1, category relationship of the two known categories had a significant effect on mean diagramming times for correct items ($F = 5.41$, $df = 3{,}54$, $p<0.01$). Table 2.27 shows that within condition 1, those items which contained set-overlap (O) known category relationships were diagrammed significantly slower than those items which contained set-exclusion (E) or set-inclusion (S and H) known category relationships.

Table d (Appendix 5) shows that within condition 2, known category relationship also had a significant effect on mean diagramming times for correct items ($F = 5.70$, $df = 3{,}54$, $p<0.01$). Those items which contained set-overlap (O) category relationships were diagrammed significantly slower than those items which contained set-exclusion (E) or the H set-inclusion known category relationships (see Table 2.27). Unlike condition 1, within condition 2 no significant difference was detected between O and S items.

Within condition 3, known category relationship did not have a significant effect on mean diagramming times for correct items; $F = 2.47$, $df = 3{,}48$, n.s. (Table e, Appendix 5)

For known category relationships, it is apparent that differential effects on diagramming times occur within conditions 1 and 2 but not within condtion 3.

Diagramming errors

(i) Diagramming errors between experimental conditions 1, 2 and 3

Table 2.28 below gives means and standard deviations for subjects' diagramming errors committed in the three experimental conditions.

	$\overline{X}$	S.D.
CONDITION 1	6.28	3.40
CONDITION 2	4.71	4.44
CONDITION 3	8.04	4.27

Table 2.28 Means and standard deviations for errors in the three experimental conditions

A one-way analysis of variance (CR-3 design; Kirk, 1968) was calculated for number of diagramming errors made in the three experimental conditions. The analysis of variance summary table is given in Appendix 5 (Table f). For this analysis, a significant difference was detected between the three experimental conditions ($F = 3.53$, $df = 2,62$, $p<0.05$). A subsequent Tukey's multiple comparision of means procedure revealed that the only significant comparison was Condition 2 < Condition 3 ($p<0.05$) for diagramming errors.

(ii) Type a errors (i.e. incorrectly diagramming a set-overlap instead of a set-inclusion) between experimental conditions 1, 2 and 3

The percentage type a errors of total errors in the three experimental conditions was 50.8% for condition 1, 22.2% for condition

2, and 33.1% for condition 3. Table 2.29 below gives means and standard deviations for subjects type a diagramming errors in the three experimental conditions.

	$\bar{X}$	S.D.
CONDITION 1	3.19	3.96
CONDITION 2	1.04	1.28
CONDITION 3	2.71	2.55

Table 2.29 Means and standard deviations for type a errors in the three experimental conditions.

A one-way analysis of variance (CR-3 design) was calculated for number of type a diagramming errors committed in the three experimental conditions. The analysis of variance summary table is given in Appendix 6 (Table g). For this analysis, a significant difference was detected between the three experimental conditions ($F = 4.71$, $df = 2,62$, $p<0.05$). A subsequent Tukey's multiple comparison of means procedure revealed that for type a errors:

Condition 2 < Condition 1 ($p<0.05$)

Condition 2 < Condition 3 ($p<0.05$)

It is apparent that significantly less type a errors were made in condition 2 compared with conditions 1 and 3. No significant difference was found between condition 1 and condition 3 for type a errors.

(iii) Diagramming errors on balanced items between experimental conditions 1, 2 and 3

As explained previously, balanced items are those where the unknown category has the same set-relationship to both known categories in a stimulus item (see Fig. 2.10). Means and standard deviations for subjects' diagramming errors on balanced items in the three experimental conditions are given in Table 2.30 below.

	$\overline{X}$	S.D.
CONDITION 1	3.00	1.95
CONDITION 2	1.45	2.09
CONDITION 3	3.48	2.56

Table 2.30 Means and standard deviations for diagramming errors on balanced items in the three experimental conditions

A one-way analysis of variance (CR-3 design) was calculated for number of diagramming errors committed for balanced items in the three experimental conditions. The analysis of variance summary table is given in Appendix 5 (Table h). For this analysis a significant difference was detected between the three experimental conditions ($F = 4.11$, $df = 2,62$, $p<0.05$). A subsequent Tukey's multiple comparison of means revealed that the only significant difference was Condition 2 < Condition 3 ($p<0.05$). Less errors were made on balanced items in Condition 2 than in Condition 3.

(iv) Diagramming errors on unbalanced items between experimental conditions 1, 2 and 3

Unbalanced items are those where the unknown category has a different set-relationship to both known categories in a stimulus item (see Fig. 2.10). Means and standard deviations for subjects diagramming errors on unbalanced items in the three experimental conditions are given in Table 2.31 below.

	$\bar{X}$	S.D.
CONDITION 1	3.29	2.00
CONDITION 2	3.24	2.79
CONDITION 3	4.29	2.41

Table 2.31 Means and standard deviations for diagramming errors on unbalanced items in the three experimental conditions

A one-way analysis of variance (CR-3 design) was calculated for number of diagramming errors made on unbalanced items in the three experimental conditions. The analysis of variance summary table is given in Appendix 5 (Table i). For this analysis no significant differences were detected between the three experimental conditions. ($F = 1.25$, $df = 2,62$, n.s.)

(v) Diagramming errors on balanced and unbalanced items within the three experimental conditions

Correlated 't' tests were calculated for subjects' diagramming errors on balanced and unbalanced items within each experimental condition. For condition 1 $t = 1.09$, $df = 8$, n.s. For condition 2 $t = 3.75$, $df = 8$, $p<0.01$; in this condition signficantly more errors were made when subjects were diagramming unbalanced items. For condition 3 $t = 1.26$, $df = 8$, n.s. The significant difference detected between errors committed on balanced and unbalanced items in condition 2 can be accounted for by the relatively low number of errors made on balanced items within condition 2.

(vi) Diagramming errors on O, E, S and H items within each of the experimental conditions

Means and standard deviations of diagramming errors for the four known category relationships under the three experimental conditions are given in Appendix 5 (Table j). A randomised block analysis of variance (RB-4 design; Kirk, 1968) was calculated for mean errors on O, E, S and H items for each of the experimental conditions. These three analysis of variance summary tables are given in Appendix 5 (Tables k, l, and m). It can be seen from these tables that the category relationship of the known items had a significant effect on errors within all three experimental conditions. Tukey's multiple comparison of means procedures revealed that the differences were located as shown in Table 2.32.

It can be seen from Table 2.32 that the pattern of results for errors for the four category relationship (i.e. O, E, S and H) item types are identical for condition 1 and condition 3. In both these conditions significantly less errors are made on E items compared with all others (O, S or H). However, for condition 2 it is apparent that

	F	p	TUKEY'S MCOM SIGNIFICANT CONTRASTS	p
CONDITION 1 (supersets before subsets	8.18 (df = 20,60)	<0.01	O > E S > E H > E	<0.01 <0.01 <0.01
CONDITION 2 (subsets before supersets)	9.79 (df = 20,60)	<0.01	O > E O > S H > E	<0.01 <0.01 <0.01
CONDITION 3 (subjects' choice)	8.00 (df = 20,60)	<0.01	O > E S > E H > E	<0.01 <0.01 <0.01

Table 2.32 RB-4 Analyses of variance and significant contrasts for the category relationship of known items (i.e. O, E, S or H) on subjects mean errors within each experimental condtion

there is no significant difference between E items and S items (i.e. those with a set-inclusion known category relationship, where the subset category occurs in the first premise). For H items (i.e. those with a set-inclusion known category relationship, where the superset category occurs in the first premise) significantly more errors are made compared with E items in condition 2 (as in conditions 1 and 3).

(vii) <u>Percentage alternative correct diagramming solutions within the three experimental conditions</u>

The alternative correct diagrams are those which contain a set-inclusion solution to a "some" premise and are shown in Fig. 2.10. The percentage alternative correct diagrams drawn were calculated for the three experimental conditions. For condition 1, percentage alternative correct diagrams was 0.7%. For condition 2, percentage alternative correct diagrams was 1.9%. For condition 3 percentage alternative correct solutions was 8.4%. These alternative solutions were rarely diagrammed in all three experimental conditions.

Unknown category naming time

After diagramming each stimulus item, subjects were required to suggest a category name for the unknown category. Means and standard deviations for subjects unknown category naming times in each experimental condition are given in Table 2.33 below.

	$\overline{X}$	S.D.
CONDITION 1	8.26	3.68
CONDITION 2	8.73	4.30
CONDITION 3	11.00	4.87

Table 2.33 Means and standard deviations for unknown category naming times in the three experimental conditions

Mean times for each subjects correct category suggestions were compared between the three experimental conditions using a one-way analysis of variance (CR-3; Kirk, 1968). The analysis of variance summary table is given in Appendix 5 (Table n). For this analysis a significant difference was detected for the three experimental conditions (F = 23.11, df = 2.60, p<0.01). A subsequent Tukey's multiple comparison of means procedure revealed that for mean unknown category naming time Condition 1 < Condition 3, and Condition 2 < Condition 3. In both constrained conditions, therefore, subjects were able to correctly generate suggestions for unknown categories quicker than in the unconstrained condition.

Unknown category naming errors

Means and standard deviations for subjects unknown category naming errors are given in Table 2.34 below.

	$\overline{X}$	S.D.
CONDITION 1	5.90	2.34
CONDITION 2	6.14	3.11
CONDITION 3	4.66	2.68

Table 2.34 Means and standard deviations for unknown category naming errors in the three experimental conditions

The frequency of unknown category naming errors were compared between the three experimental conditions (CR-3 type analysis of variance; Kirk, 1968) and the summary table is given in Appendix 5 (Table o). No significant difference was detected (F = 1.14, df = 2,60, n.s.). No differences in unknown category naming errors were apparent between the constrained (conditions 1 and 2) and unconstrained (condition 3) experimental conditions.

Summary of main results

1. Compared with condition 3 (subjects' choice of output sequence), condition 2 (instructing subjects to diagram subsets before supersets) has a number of beneficial effects on performance:

(a) Less diagramming errors

(b) Less type a errors (i.e. incorrectly diagramming a set-overlap instead of a set-inclusion)

(c) Less diagramming errors on balanced items (i.e. those items where the unknown category has the same set-relationship to both known categories).

(d) Faster unknown category naming time (for correct suggestions)

2. Compared with condition 3, condition 1 (instructing subjects to diagram supersets before subsets) has a significant beneficial effect on performance only with respect to faster unknown category naming time (for correct suggestions).

3. Significantly more errors were made on unbalanced items compared with balanced items in condition 2. This was not the case in conditions 1 and 3.

4. For items with different known category relationships differential effects are observed on subjects' mean correct diagramming times in conditions 1 and 2. This is not the case for condition 3 (see Table 2.27).

5. For items with different known category relationships, the pattern of results for diagramming errors is identical for conditions 1 and 3.

In condition 2, S items (i.e. those items with a set-inclusion known category relationship where the subset component is included in the first premise and the superset component is included in the second premise) are not associated with more errors than E items (i.e. those items with a set-exclusion known category relationship), unlike conditions 1 and 3 where S > E for diagramming errors (see Table 2.30). In all three experimental conditions H items (i.e. those items with a set-inclusion known category relationship where the superset component is included in the first premise and the subset component is included in the second premise) are associated with significantly more diagramming errors than E items.

6. Unknown category naming time (for correct suggestions) is significantly faster in conditions 1 and 2 compared with condition 3.

Discussion

It has been suggested that imposing constraints on subjects' diagramming sequences would have two general effects on subjects performance in the diagramming relationships task, when subjects are integrating an unknown category into what they already know. Firstly, imposing any constraint on output sequence should induce a more complete evaluation of the set-relationship among the three categories in a stimulus item when the imposed output sequence does not match the subject's choice of output sequence. Consequently, in the constrained experimental conditions (i.e. conditions 1 and 2) it is suggested that subjects become more dependent on an inference strategy of the type outlined previously (Experiment 4) compared with subjects who are unconstrained in their output sequence (i.e. condition 3).

It can be seen from Table 2.27 that differential effects are observed for subjects' mean correct diagramming times on items with different known category relationships in conditions 1 and 2, whereas this is not the case in condition 3. This might suggest that in the constrained conditions (i.e. conditions 1 and 2) subjects are dependent on an inference strategy of the type proposed in Experiment 4, whereas this is not the case in the unconstrained condition (i.e. condition 3). The finding that in both constrained conditions subjects generated correct unknown category suggestions significantly faster than subjects in the unconstrained condition, further suggests that subjects have better comprehended the relationships among the three categories in stimulus items in constrained conditions. Presumably, this improved comprehension in conditions 1 and 2 stems from a more complete evaluation of the three categories in a stimulus item.

The suggestion that more errors would be made on unbalanced items (i.e. those items in which the unknown category has a different set-relationship to both known categories) compared with balanced items (i.e. those items in which the unknown category has the same set-relationship to both known categories) in condition 3 has not been supported ($t = 1.26$, $df = 8$, n.s.). The specific suggestion that subjects tend not to evaluate remote category pairs has therefore not been supported.

The finding that in condition 2 significantly less type a errors are made than in condition 1 and condition 3 supports the directional effect postulated in the proposed inference strategy (see Fig. 2.8, Experiment 4). In the proposed inference strategy, the order in which subjects allocate the subset and superset components of the to-be-evaluated set-inclusion category pairs in their self-addressed questions is related to the probability of making type a errors. It is suggested that instructing subjects to diagram subsets before supersets when they encounter a to-be-diagrammed set-inclusion (i.e. condition 2) in a stimulus item has the effect of inducing subjects to consider the subset as the first term in their second self-addressed question (Fig. 2.8, Experiment 4). Instructing subjects to diagram supersets before subsets (i.e. condition 3) has the effect of inducing subjects to consider the superset as the first term in their second self-addressed question. Consequently more type a errors are made in condition 1 compared with condition 2. Since, in condition 3 subjects can, and do, diagram supersets before subsets more type a errors are made in this condition compared with condition 2. The finding that significantly fewer errors were made on balanced items in condition 2 compared with condition 3 is probably accounted for by the fact that balanced items contain more set-inclusions than unbalanced items (see Fig. 2.10).

It can be seen from Table 2.32 that unlike conditions 1 or 3, in condition 2 the frequency of errors on S item types is not significantly different from the frequency of errors on E item types. This is not the case on H item types for which significantly more errors are made compared with E item types in all three experimental conditions. The difference between S and H item types is in the location of the subset and superset components of the known set-inclusion category relationships in the premises of stimulus items. The beneficial effect on type a errors of instructing subjects to diagram subsets before supersets occurs for items where the subset component of a to-be-diagrammed set inclusion known category relationship occurs in the first premise, and the superset in the second premise. Sequence is a critical variable in the present task with respect to both the order in which subjects evaluate categories and the order in which categories are presented.

Conclusions

Specifying some of the strategies which subjects utilise in incorporating an unknown category into their existing cognitive structures has led to a clear instructional procedure which results in improved comprehension. The implications of the present findings are considered in greater detail in the subsequent discussion of this unit of experiments.

2.10 DISCUSSION OF UNIT 2 (EXPERIMENTS 4, 5 AND 6)

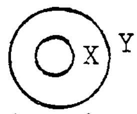
Three experiments were presented in Unit 2 which used the diagramming relationships methodology. This methodology was introduced and described in Section 2.6.2 and is one means in which the central issue of how new information is incorporated into an individual's cognitive structure can be examined. The purpose of this discussion is to summarise the main results of the unit in relation to cognitive structures, strategies and instruction.

2.10.1 Structures and strategies in the diagramming relationships experiments

A set-theoretic approach to both semantic representation and the structure of experimental materials has been utilised in the diagramming relationships experiments. Generally the experimental results relating to various views of the structure of semantic representation (some of which have been discussed in Sections 1.3.2 and 2.6.1) are equivocal because semantic distance, category size and conjoint frequency are often unavoidably confounded. Further, many theorists use "process" and "structure" type concepts interchangeably and although it is generally assumed that cognitive structures determine relevant processes, it is also apparent that the establishment of cognitive structures is a function of certain cognitive processes. As G. Mandler (1979) has pointed out, it may be premature to make strong distinctions between processes and structures. It may be preferable to specify what is conceived of as structure and what is conceived of as process within the confines of each theoretical attempt at describing performance. The key methodological issue is to attempt to separate out cognitive structures from cognitive strategies.

Experiment 4 has demonstrated that there were clear performance differences between the manner in which subjects diagrammed stimulus items which contained three known categories (known items) and those which contained two known categories and one unknown category (unknown items). The results showed that the structure of subjects existing knowledge, described in set-theoretic terms, affected subjects' diagramming times although the pattern of results differed for known and unknown items. However, this does not, of course, necessarily support the notion that semantic memory is structured in set-theoretic terms. The concept of cognitive representation is complex and as Palmer (1978) has pointed out the 'pictures' we draw must not be confused with the representational assumptions contained in the theory itself.

A variety of strategies of information processing could account for the results of Experiment 4. It was tentatively proposed that one inference strategy might account for some of the results. The proposed inference strategy has been discussed in some detail in the discussion of Experiment 4. Briefly, the strategy consists of a sequence of self-addressed questions and subjects are primarily considered to make errors by not asking the logically complete set of self-addressed questions in order to evaluate the set-relationship of category pairs in stimulus items. An assumption in the strategy is that individuals evaluate categories as pairs and construct their diagrammed responses by assembling these category pairs. A number of alternative explanations might involve the evaluation of combinations of categories in various ways. For example in the proposed inference strategy one self addressed question is "are some X,Y ?", whereas subjects might ask "are some X and Y,Z ?"or "are some X and Z, Y?" etc. These alternative strategy components could obviously be developed into more complex models.

A critical part of the inference strategy concerns the order in which subjects allocate the subset and superset components of a to-be-evaluated set-inclusion category pair in their self-addressed question. Consider a to-be-evaluated set-inclusion of the form 

Subjects who choose to allocate the subset category to the first term position in their second self-addressed question (i.e. "are all X,Y ?") are less likely to make type a errors (i.e. incorrectly diagramming a set-overlap instead of a set inclusion) than subjects who choose the superset as their first term in their second self-addressed question (i.e. "are all Y,X?"). Type a errors accounted for the large majority of all errors made when subjects were diagramming both known and unknown items.

In Experiment 4 subjects tendency to consider supersets before subsets (as inferred from their diagramming sequences) was found to be positively correlated with the frequency of type a errors made when diagramming known items. When diagramming unknown items, there was no significant relationship between subjects directional tendency in diagramming subsets and supersets and frequency of type a errors committed. Further, since the proposed inference strategy was better able to account for diagramming times on known items than on unknown items, it was suggested that subjects were not completely evaluating the set-relationships of all three categories in unknown stimulus items and were consequently not relying on the inference strategy. This was tentatively inferred from differences in subjects' output sequences for correct and incorrect diagrams for unknown stimulus items.

Wickelgren (1979) has suggested that quantified premises are particularly difficult to evaluate since although quantifiers are basic to predicate logic, unquantified thinking appears to be basic to human semantic memory. Wickelgren (1979) supports an associative network view of semantic memory structure. Experiment 5 attempted to shed light on the issue of evaluating quantified and unquantified information by presenting the categories used in known items in Experiment 4 in an unquantified ("list") format rather than in a quantified ("syllogistic") format (as in Experiment 4). Quantified statements are unnecessary to the task of diagramming relationships when all three categories of stimulus items are known to subjects. The results showed that in diagramming identical sets of three known categories, clear performance differences were apparent depending on the format in which the categories were presented. The pattern of diagramming times differed between the two presentation formats, although the mean diagramming times for the nine item types in the two formats were positively correlated.

The unquantified ("list") format stimulus items were diagrammed significantly faster than the quantified ("syllogistic") format stimulus items. It appeared that subjects may be utilising or distracted by quantifiers even when they are not necessary to the diagramming task.

Output sequence in the diagramming relationships task is considered to reflect some aspects of the cognitive processes related to search and retrieval from semantic memory. Clear differences were apparent in subjects output sequences between the two presentation formats. Consequently, different cognitive processing might underly performance in the diagramming task under unquantified or quantified presentations.

The majority of errors made in both Experiments 4 and 5 were type a errors (i.e. incorrectly diagramming a set-overlap instead of a set-inclusion). Unlike known items in Experiment 4, no significant positive correlation was apparent between subjects' tendency to diagram supersets before subsets and the frequency of type a errors in the unquantified presentation of Experiment 5.

Performance on the diagramming task depends on the complex interaction between the presentation format, the structure of prior knowledge and the cognitive strategies subjects utilise.

2.10.2 Experimenter imposed strategies and performance

As in Experiment 4, Experiment 6 utilised stimulus items consisting of two known categories and one unknown category. In Experiment 6 constraints were imposed on the sequence in which subjects could diagram the three circles representing the three categories of a stimulus item. These constraints were related to the sequence in which subjects could diagram the superset and subset components in any to-be-diagrammed set-inclusion category pair they encountered in stimulus items. Three instructional conditions were used in Experiment 6.

In Condition 1 subjects were instructed to diagram supersets before subsets in any to-be-diagrammed set-inclusion they encountered in stimulus items.

In Condition 2 subjects were instructed to diagram subsets before supersets in any to-be-diagrammed set-inclusions they encountered in stimulus items.

In Conditon 3 subjects were instructed to diagram subsets and supersets in any order they chose in any to-be-diagrammed set-inclusions they encountered in stimulus items.

When subjects were attempting to integrate an unknown category into their previously acquired cognitive structure, it was suggested that constraining subjects' diagramming sequences (Conditions 1 and 2) would have the effect of inducing subjects to more completely evaluate the set-relationships among the three categories of the stimulus items. This was considered to be the case since imposed output sequence would not always match the subjects' choice of output sequence.

The results showed that in both constrained instructional conditions subjects generated correct suggestions for unknown categories significantly faster than in the unconstrained instructional condition (Condition 3). The speed at which subjects could generate an example of the unknown category was considered to be a measure of comprehension as was unknown category naming errors, although no differences were detected between the three instructional conditions on this error measure.

In the proposed inference strategy which has been described previously, the order in which subjects allocate the subset and superset components of a to-be-evaluated set-inclusion category pair in their self-addressed questions is suggested to be related to the probability of making type a errors (i.e. incorrectly diagramming a set-overlap instead of a set-inclusion).

The results have suggested that imposing constraints on subjects' diagramming sequences induce a more complete evaluation of the three categories in a stimulus item. Consequently it has been further suggested that when subjects were more completely evaluating categories they would become dependent on the proposed inference strategy. When subjects were instructed to diagram supersets before subsets (Condition 1) it was suggested that this would induce subjects to consider the superset as the first term in their second self-addressed question in their inference strategy. Conversely, when subjects were instructed to diagram subset before supersets (Condition 2) it was suggested that this would induce subjects to consider the subset as the first term in their second self-addressed question in their inference strategy. The results clearly demonstrated that significantly more type a errors were made in Condition 1 compared with Condition 2. Condition 2 was also associated with less type a errors than Condition 3 where subjects were unconstrained and diagrammed supersets before subsets in some set-inclusions.

An interesting additional finding in Experiment 6 was that the beneficial effect on reducing type a errors in instructional Condition 2 only tended to occur for stimulus items where the subset component of a set-inclusion known category pair occurs in the first premise (and the superset component in the second premise) in a stimulus item. This was not the case for stimulus items where the superset and subset components of a set-inclusion known category pair occurred in the first and second premises respectively.

It is clear that both the external sequencing of categories in the experimental material and the internal sequencing of categories in subjects' processing strategies are important in understanding performance on the diagramming relationships task.

2.10.3 Conclusions

The diagramming relationships methodology has been demonstrated to be a useful way in which some of the dynamics of processing can be investigated when new information is being incorporated into an individual's previously acquired cognitive structure.

The results have shown that the structure of previously acquired knowledge is related to performance on the diagramming relationships task, although processing strategies are at least as important as structural considerations.

Although a set-theoretic interpretation of both the structure of the experimental materials and the structure of semantic memory has been a useful methodological vehicle, the results do not necessarily support a set-theoretic view of the representation of semantic memory.

It has been suggested that the processes which underly comprehension when known categories are presented in a quantified ("syllogistic") format appear to differ from the processes which underly comprehension when known categories are presented in an unquantified ("list") format.

It is apparent that the identification of cognitive processes related to successful task performance (specified in the proposed inference strategy) has led to clear instruction procedures which result in improved comprehension when new information is being assimilated.

PART 3

PART 3 - CONCLUSIONS AND IMPLICATIONS

3.1 THE CONCEPT OF LEARNING

3.2 INSTRUCTIONAL TASK ANALYSIS AND DESIGN

3.2.1 Unit 1 : Issues and implications
3.2.2 Unit 2 : Issues and implications

PART 3 - CONCLUSIONS AND IMPLICATIONS

The range and diversity of theories, hypotheses and experimental studies relevant to questions about learning and understanding is immense. Some of the contemporary approaches to these questions have been considered in some detail in Part 1 of this thesis. Part 1 has provided an organisational framework which is congruent with the ideas of many contemporary theorists. Three critical components of a cognitive approach to the problems of instructional task analysis and design were identified. These components are considered to be the structure of the subject matter, the cognitive structure of learners, and the cognitive strategies the learner brings to bear on the instructional material and which act as control and transfer devices. Performance in any instructional system is determined by a complex set of relationships among these three components. The purpose of the final part of this thesis is to briefly overview important issues within these three critical components in relation to the experimental work reported in Part 2. The salient results of the two units of experiments in Part 2 have been summarised in the discussion following each unit (Sections 2.5 and 2.10). Some of these results are considered at appropriate points in the ensuing discussion. Potential implications for future theoretical developments and research are suggested.

3.1 THE CONCEPT OF LEARNING

Since the cognitive approach has replaced behaviourism as the dominant school of thought in experimental psychology what is currently entailed by the concept of learning is less than clear. Although any complete cognitive learning theory has not yet been developed, what is apparent is that the processes which underly learning are not distinct from the processes which underly other psychological functions such as perception, memory, language and thinking. Cognitive psychology focuses on those theoretical processes which are common to what was once conceived of as fairly well demarcated functions of the mind. The generality of the cognitive approach can be seen in a variety of theoretical efforts. For example, current investigations of semantic memory representations and processes have implications for an understanding of retention and retrieval as well as for the acquisition of knowledge. As Voss (1979) has observed, the concept of learning now requires the inclusion of the acquisition of rules and strategies in addition to the central issue of the assimilation of information into knowledge structures. It is becoming increasingly clear that cognitive theory should view learning as a transfer phenomenon in which initial learning consists of the cognitive structures and strategies which the individual brings to the learning situation. These prerequisites to effective learning not only refer to what the learner knows (declarative knowledge) but also to the skills the individual has developed in learning how to learn (procedural knowledge). The problem of assessing the initial state of the learner is particularly important because both declarative and procedural knowledge must be taken into account. An individual's previously acquired knowledge and skills can greatly facilitate the acquisition of new information. If instructional techniques are to be developed in which information is structured and presented in a form consistent with the learner's current knowledge and skills, then the specification of any individual's initial state is central.

This criticality of initial state has been emphasised by many instructional psychologists who have generally contended that no one instructional technique can provide optimal learning for all students. However, previous approaches to individualising instruction (notably aptitude-treatment interaction research - reviewed in Section 1.4.2) have led to a mass of data which is difficult to render meaningful. This has occurred because attempts to assess learner's previously acquired knowledge and skills have generally used aptitude and ability tests which sample a range of processes. These psychometric measures are blunt instruments for the purpose of initial state assessment and what is required is increased research into the mental processes that underly learner's activities. The specification of these mental processes which function to encode and transmit information form the basis of a variety of learning strategies which act as transfer devices between the instructional material and long-term memory. These strategies are diverse in their detailed forms and have previously been discussed in some detail (Section 1.4).

The approach adopted in this thesis has been that the effectiveness of learners can be improved by understanding the strategies they engage in andby designing the learning evironment to encourage the utilisation of successful strategies. Instructional task analysis and design are central in the development of an effective cognitive approach to the problems of instruction.

3.2 INSTRUCTIONAL TASK ANALYSIS AND DESIGN

Instructional task analysis and design attempts to describe entry behaviour, to analyse performance into components, and to organise suitable sub-task sequences in order to define and structure what a learner must master. One useful approach to instructional task analysis is the identification of learning strategies associated with successful task performance. A key concern in the experiments of Part 2 has been to identify learning strategies which play a central role in the learner's active selection and transformation of instructional material. Although the variety of materials included in instructional systems is extremely large, it is clear that an understanding of the structure of these materials in an important consideration for the application of a learner's strategies. Some approaches to the analysis and organisation of instructional materials have been reviewed in Section 1.2.

Since effective learning is a function of the relationship of the material to-be-learned and an individual's cognitive structures and strategies, the central concern for instructional design is to attempt to develop instructional methods and materials which encourage the use of appropriate learning strategies.

Both units of experiments in Part 2 of this thesis proceed from instructional task analysis to instructional design. Initially, in the task analysis phase cognitive strategies related to successful performance were identified. The approach in both units of experiments has initially been to allow learners some amount of freedom in the experimental situation in order to reveal a range of strategies within the subject pool selected. These strategies can vary within and between subjects. Following identification of successful strategies, attempts were made to arrange conditions in the experimental environment to induce learners to utilise successful strategies in order to improve performance on the selected tasks.

The specific results of each of the six experiments reported have been discussed at the conclusion of each experiment. A summary and discussion of the main results of each unit of experiments has been presented in Sections 2.5 and 2.10 for Unit 1 and Unit 2 respectively. More general issues and implications for further research are considered subsequently.

3.2.1 Unit 1 : Issues and implications

Herriot (1974) suggested that future research into organisational processing should utilise experimental materials which had alternative possible modes of organisation. This approach was adopted with the experimental materials utilised in the experiments of Unit 1 in order to examine how subjects processing was influenced by the material sequence and organisation (either learner or experimenter controlled). The materials were constructed from concept name by concept attribute matrices (a procedure suggested by Frase, 1969) and organisation at acquisition and recall was examined in relation to recall performance. This methodology proved a useful way in which some of the relationships between input organisation, output organisation and recall could be investigated.

From the instructional viewpoint the experiments supported the notion that under certain conditions subjects could utilise the concept name and concept attribute external organisers in order to enhance recall. The relationships between input organisation, output organisation and recall were complex and varied both as a function of learner or experimental control and presentation as "items" or passages. It was suggested that it was important to consider the mapping of the external organisers both onto the instructional content and the learners previously acquired knowledge and skills. The potential usefulness and generality of these particular organisational categories depends on their utility in describing both textual structure and some aspect of cognitive structure. Previous research (Frase, 1969; Schultz and DiVesta, 1972) had provided some evidence relating to dominant clustering by concept name in recall which was suggested to be usefully conceived of as a simple "event schema" relating to subject's expectation of organisation by concept name in instructional material. Consequently, if instructional material is structured and presented in a form consistent with this expectation then recall should be enhanced. Only tentative and indirect support could be offered in Unit 1 for the notion that learners have a stereotypic expectation concerning the organisation of the instructional materials. Clearly further investigation is required to specify the conditions under which this event schema might be activated. One potential methodological problem in further investigation relates to the assumption that the sequence of textual units (e.g. words, sentences, paragraphs, etc.) is the sequence in which subjects choose to select and attend to those units in their preferred acquisition strategies. This was shown to be a critical factor when the instructional material was presented as discrete "items". If future research utilises normal textual material (where it might be assumed that activation of the event schema is more likely) then experimental control of subjects' acquisition strategies becomes difficult.

Generally research directed to uncovering "subject-matter" schema in a variety of contexts would appear to be a productive effort in optimising the design of instructional materials. More specifically, the concept that organised structures or schemata exist in memory and input information is processed in terms of such structures, could clarify the common instructional notion that the structure of instructional materials may be able to prescribe the instructional sequence. Duncan (1972) has pointed out that the central methodological problem in this area is one of finding instructional sequences which are both intelligible and yet do not violate the sequence suggested by the structure of the subject-matter. However, the answer to the question of what constitutes an intelligible sequences does not reside purely in the structure of the subject-matter. An intelligible sequence also depends on the learner's previously acquired cognitive structures and strategies. Optimal instructional sequences must take both subject-matter characteristics and learner characteristics into account. Further research is clearly required to specify the relative contributions of subject-matter and learner factors in a variety of instructional contexts. However, in research directed to these ends one major methodological problem resides in the complexity of the instructional materials used. The experiment of Unit 1 for example, although utilising somewhat restricted and artificial materials had the benefit that the content structure was well specified. Frase

(1973) has observed that there is a need to obtain a proper balance between ordinary materials (the structure of which is not well understood by the experimenter) and artificial materials (the structure of which is well understood by the experimenter). A proper balance needs to be achieved between the clarity of experimental design and the relevance of experimental materials.

One experiment which has not been reported in full because it did not effect this balance is briefly described at this point in order to highlight Frase's (1973) observation and the inadequacy of intuitive analysis in research on organisational aids.

A section of an instructional text on the chemistry of proteins (Taylor, 1964) was partitioned into fourteen paragraphs and organised into a four-level rooted hierarchy on the basis of Ausubel's (1963) hierarchical notions. The most "abstract, general, stable and inclusive" ideas in one paragraph formed the apex of the hierarchy and lower levels were identified with paragraphs containing progressively more specific and stable ideas. Subjects were presented with the "empty" hierarchical structure and were required to read the paragraphs (which were each printed on separate cards) and to place the cards at what they felt to be the appropriate points in the hierarchy. The experiment was repeated with a different set of subjects who could only read paragraph titles (which were each printed on separate cards) and to place the cards at what they felt to be the appropriate points in the hierarchy. The paragraph titles were assumed to be brief abstracted descriptions of the paragraph contents to which they referred.

The results indicated that subjects could generally perceive the structure of the subject-matter, as intuitively defined by the experimenter, using paragraphs or paragraph titles. However, the results were difficult to interpret because of the ill-defined nature of the structural linkages both between paragraphs and between paragraph content and paragraph titles. In using ordinary material in which the underlying structure is poorly understood by the experimenter, little can be said about the validity of the psychological model which underpins the intuitive analysis of the instructional material into paragraph "units". Much of the research on organisational aids has proceeded on an intuitive basis and the results are equivocal since they rely on the competence of the person engaged in the analysis. More research should be directed to the question of how organisational aids map both onto the instructional content and the learners previously acquired knowledge and skills.

However, it is also apparent that subjects may not choose to utilise an organisational aid even if provided. Consequently as G. Mandler (1979) has observed to know as much as possible about the expectancies, knowledge and intention of learners is critical. The relationships between the structure of the subject-matter and the learners' cognitive structures and strategies are necessary in attempting to optimise the structure and sequence of instructional materials.

3.2.2 Unit 2 : Issues and implications

Although the role of subjects' previously acquired knowledge and skills were considered to be important in the tasks investigated in

Unit 1, the experiments of Unit 2 examined the assimilation of new information into an individuals previously acquired cognitive structure more directly. The experiments of Unit 2 represent another context in which the structure of the instructional materials and the learner's cognitive structures and strategies were examined. A particular methodology was developed and utilised and this methodology has been described in detail in Section 2.6.2. This methodology provided was found to be useful in examining some aspects of processing by which unknown categories were assimilated. As in the experiments of Unit 1, the initial step was the identification of cognitive strategies related to successful task performance (Experiments 4 and 5) and in a subsequent experiment (Experiment 6) conditions were arranged in the experimental environment to induce subjects to utilise effective processing operations. The experiments of Unit 2 have raised several issues which are further discussed below.

One of the central questions in the study of cognitive processes concerns the form in which information is stored in memory. Many experiments and theories have explored and attempted to describe the nature and structure of this stored information (a number of these have been reviewed in Section 1.3.). Although attempts to specify people's underlying knowledge structures is an extremely important endeavour, it should not be viewed as an end in itself. As Anderson and Bower (1973) have observed the choice of the representation is central since it has widespread implications for the manner in which this 'information-file" is accessed, searched and utilised when information is being processed. The diagramming relationships methodology is one small way in which the effects of representations of information and the processes of assimilating new information can be examined. The application and implications of this type of research using other similar methodologies could be important in shedding light on the central instructional issue of how people understand new information.

The question of what it means to "understand" is beginning to play an increasingly important role in contemporary cognitive psychology. A major impetus in highlighting the importance of this question has come from recent work on problem-solving (e.g. Greeno, 1973, 1977; Hayes and Simon, 1976). A variety of descriptions can of course be applied to what it means to understand. A number of theorists (e.g. Schank, 1972; Winograd, 1972) have viewed understanding as a constructive process in which a representation is developed for the object that is understood. The revival of the constructivist approach is partly due to results derived from sentence memory research (e.g. Barclay, 1973; Bransford and Franks, 1972; Kintsch and Monk, 1972). These studies have suggested that when a person understands meaningful verbal material he educes a cognitive structure for its meaning. In other words, when verbal material is understood, its internal representation shows what the material means. The meaning corresponds to a pattern of relations among concepts that are included in the input material, and understanding is the act of constructing such a pattern. In order to construct an internal representation, the understander relies on his previously acquired knowledge. This previously acquired knowledge often includes knowledge of what the words in the input refer to and also more subtle conceptual knowledge that constrains the construction of the representation whilst enabling inferences to be drawn from semantic memory.

In the diagramming relationships methodology a set-theoretic description has been applied to both the experimental materials and semantic representation. Some approaches to the problem of semantic representation have been reviewed in Sections 1.3.2 and 2.6.1. Since it appears that no unique structural representation exists for any linguistic input and the internal representation is suggested to denote what an input means then it is apparent that to determine whether something has been understood is a speculative enterprise. However, given these misgivings it is suggested that the completeness or adequacy of understanding can be usefully discussed in relation to the diagramming relationships experiments.

Greeno (1977) has suggested that "good understanding" involves achievement of a coherent representation. A representation can be considered to be incomplete or inadequate to the extent that some components of input remain unattached to the rest of the input. In the diagramming relationships task, the main input components under consideration are the three categories in any particular stimulus item. In Experiment 4 it was suggested that when subjects were diagramming two known categories and one unknown category they tended not to completely evaluate the set-relationships among the three categories in the stimulus items. In Experiment 6 it was suggested that constraining subjects' output diagramming sequences would result in subjects evaluating the set-relationships among categories more completely when the imposed constraint did not match the subjects' preferred output diagramming sequence. The results showed that in both constrained instructional conditions subjects generated correct suggestions for unknown categories significantly faster than in the unconstrained instructional condition. The speed at which subjects could generate an example of the unknown category was considered to be a measure of comprehension or understanding. This can be interpreted to support the notion that in the constrained instructional conditions subjects achieved more coherent representations of the input category components of stimulus items. Consequently, it might be suggested that understanding was more complete. Those subjects who do not completely evaluate the input category components can be considered to lack understanding of the diagramming relationships problem even if they generate correct diagramming solutions. The processes by which correct diagramming solutions can be achieved for particular to-be-evaluated category pairs in the diagramming relationships task even when processing is incomplete is specified in the proposed inference strategy (see Fig. 2.8, Experiment 4). For example, if subjects have asked their first self-addressed question "are (some) teachers, women?" and have correctly answered "yes" and consequently correctly diagrammed set-overlaps then these subjects lack understanding compared to subjects who proceed to their second self-addressed question "are all teachers, women?". Those subjects who correctly answer "no" and consequently correctly diagram a set-overlap, lack understanding compared to subjects who proceed to their third self-addressed question, "are all women, teachers?". Those subjects who correctly answer "no" and consequently diagram a set-overlap can be considered to have complete understanding of the to-be-evaluated category pair.

The constrained instructional conditions of Experiment 6 represent only a very small sample of the ways in which subjects may be induced to change their processing operations. It would be useful to investigate a variety of other constraining conditions and their effects on diagramming performance. Research is also needed to understand the processes by which subjects are able to suggest examples for unknown categories in order to understand in precisely what ways this task is a measure of comprehension or understanding.

Hayes and Simon (1976) have emphasised that the more accurate the representation of the concepts and relations in the input the greater the level of understanding. In other words the correspondence between the internal representation and the object that is understood can possibly be used as a general criterion by which the completeness of understanding may be assessed (Greeno, 1977). Many inaccuracies probably stem from random lapses of attention and results in individuals omitting relevant information in the input. This aspect of incomplete understanding was not examined in the diagramming relationships experiments.

However, more importantly an internal representation may be incomplete because that representation does not contain relations that are present in the input components. In the diagramming relationships tasks in all three experiments of Unit 2, one set-relationship among the input category components was not generally diagrammed by subjects. Whereas "no" premises can only be correctly diagrammed as set-inclusions and "all" premises can only be correctly diagrammed as set-inclusions, "some" premises may be sometimes correctly diagrammed as set-overlaps or as set-inclusions. The results have shown that subjects rarely diagrammed "some" premises as set-inclusions.

These set-relationships present among the input category components appeared not to be generally considered by subjects. Experimentation is required to assess whether understanding could be enhanced by instructing or inducing subjects to consider the set-inclusion alternative for "some" premises.

A number of researchers (e.g. Kintsch, 1975; Norman and Rumelhart, 1975) have suggested that the cognitive representations of linguistic inputs contain many propositions that are not explicit in the input. The extent to which the understood components are related to the understanders' other knowledge is clearly another important factor in considering understanding. The diagramming relationships methodology has only considered a very small part of an individuals knowledge structure. Although the experiments have demonstrated that the set-theoretic structure of known categories influences performance on the diagramming relationships task, the other known categories in an individuals knowledge structure related to that small subset actually presented in stimulus items has not been considered. Clearly additional research is required to assess the constraints and inferences a more broadly conceived knowledge structure would have on the assimilation of new information.

Understanding the relationships between the structure of instructional materials, the cognitive structures of learners and the learning strategies they engage in will ultimately have profound instructional consequences.

APPENDICES

APPENDICES

APPENDIX 1 : RESULTS SUMMARY TABLES FOR EXPERIMENT 2

APPENDIX 2 : RESULTS SUMMARY TABLES FOR EXPERIMENT 3

APPENDIX 3 : RESULTS SUMMARY TABLES FOR EXPERIMENT 4

APPENDIX 4 : RESULTS SUMMARY TABLES FOR EXPERIMENT 5

APPENDIX 5 : RESULTS SUMMARY TABLES FOR EXPERIMENT 6

APPENDIX 6 : INSTRUCTIONS FOR EXPERIMENTS 1, 2, 3, 4, 5 & 6

APPENDIX 1

RESULTS SUMMARY TABLES FOR EXPERIMENT 2

EXPERIMENT 2 (ANOVA Summary Tables a, b, c, d, e and f)

Source	SS	df	VE	F	p
Between	80.03	5	16.01	1.55	n.s.
Within	559.57	54	10.36		
Total	639.60	59			

Table a Number of cards inspected for Task 1

Source	SS	df	VE	F	p
Between	105.90	5	21.18	1.10	n.s.
Within	1036.07	54	19.19		
Total	1141.97	59			

Table b Number of cards inspected for Task 2

Source	SS	df	VE	F	p
Between	8.31	5	1.66	4.74	<0.01
Within	18.76	54	0.35		
Total	27.07	59			

Table c Recall time for Task 1

Source	SS	df	VE	F	p
Between	5.76	5	1.15	4.31	<0.01
Within	14.42	54	0.27		
Total	20.18	59			

Table d Recall time for Task 2

Source	SS	df	VE	F	p
Between	239.73	5	47.95	4.83	<0.01
Within	536.20	54	9.93		
Total	775.93	59			

Table e Recall score for Task 1

Source	SS	df	VE	F	p
Between	345.08	5	69.02	3.77	<0.01
Within	989.10	54	18.32		
Total	1334.18	59			

Table f Recall score for Task 2

	RECALL TIME			RECALL SCORE		
Number of cards inspected	COND.1	task 1	-0.24	COND.1	task 1	-0.02
	(N/N)	task 2	-0.38	(N/N)	task 2	-0.01
	COND.2	task 1	+0.15	COND.2	task 1	+0.18
	(N/A)	task 2	-0.42	(N/A)	task 2	+0.32
	COND.3	task 1	-0.13	COND.3	task 1	-0.26
	(A/A)	task 2	-0.31	(A/A)	task 2	+0.41
	COND.4	task 1	-0.62	COND.4	task 1	-0.29
	(A/N)	task 2	-0.72*	(A/N)	task 2	-0.06
	COND.5	task 1	-0.30	COND.5	task 1	-0.26
	(R/R_5)	task 2	-0.13	(R/R_5)	task 2	-0.33
	COND.6	task 1	-0.26	COND.6	task 1	+0.15
	(R/R_6)	task 2	-0.08	(R/R_6)	task 2	-0.17
Recall time				COND.1	task 1	-0.60
				(N/N)	task 2	-0.88**
				COND.2	task 1	+0.42
				(N/A)	task 2	-0.04
				COND.3	task 1	-0.11
				(A/A)	task 2	-0.44
				COND.4	task 1	+0.32
				(A/N)	task 2	+0.16
				COND.5	task 1	+0.22
				(R/R_5)	task 2	-o.29
				COND.5	task 1	-0.42
				(R/R_6)	task 2	+0.06

* $p<0.05$
** $p<0.01$

Table g Correlation coefficients for the three dependent variables of Experiment 2 within the six treatments

APPENDIX 2

RESULTS SUMMARY TABLES FOR EXPERIMENT 3

EXPERIMENT 3 (ANOVA Summary Tables a and b)

Source	SS	df	VE	F	p
Between	23.66	5	4.73	9.28	<0.001
Within	27.54	54	0.51		
Total	51.20	59			

Table a Recall time

Source	SS	df	VE	F	p
Between	1025.00	5	205.00	13.79	<0.001
Within	802.60	54	14.86		
Total	1827.60	59			

Table b Recall score

APPENDIX 3

RESULTS SUMMARY TABLES FOR EXPERIMENT 4

EXPERIMENT 4 (ANOVA Summary Tables a, b and c)

A refers to syllogistic type

a_1 is A/A/2

a_2 is I/I/4

a_3 is E/E/1

B refers to category relationship

b_1 is O

b_2 is E

b_3 is S

Source	SS	df	VE	F	p
Blocks	2456.92	9	272.99	4.02	<0.01
Treatments	1470.84	8			
A	321.72	2	160.86	2.37	n.s.
B	459.29	2	229.65	3.38	<0.05
AB	689.83	4	179.46	2.54	<0.05
Residual	4895.39	72	67.99		
Total	8823.15	89			

Table a Summary table for type RBF 3x3 design for diagramming times on all unknown items

Source	SS	df	VE	F	p
Blocks	2456.92	9	272.99	4.02	<0.01
A	321.72	2	160.86	2.37	n.s.
A at b_1	331.25	2	165.63	2.44	n.s.
A at b_2	260.45	2	130.23	1.92	n.s.
A at b_3	419.85	2	209.93	3.09	n.s.
B	459.29	2	229.65	3.38	<0.05
B at a_1	793.06	2	396.53	5.83	<0.01
B at a_2	182.58	2	91.29	1.34	n.s.
B at a_3	173.47	2	86.74	1.28	n.s.
A x B	689.83	4	172.46	2.54	<0.05
Residual	4895.39	72	67.99		
Total	8823.15	89			

Table b Summary table for simple main effects for diagramming times on all unknown items

Source	SS	df	VE	F	p
Blocks	3915.85	9	435.09	22.04	<0.001
Treatments	1126.64	8			
A	669.81	2	334.9	16.97	<0.001
B	291.21	2	145.6	7.38	<0.01
A B	165.62	4	41.41	2.10	n.s.
Residual	1421.15	72	19.74		
Total	6463.64	89			

Table c Summary table for type RBF 3x3 design for diagramming times on all known items

APPENDIX 4

RESULTS SUMMARY TABLES FOR EXPERIMENT 5

EXPERIMENT 5 (ANOVA Summary Tables a and b)

A refers to syllogistic type

a_1 is A/A/2

a_2 is I/I/4

a_3 is E/E/1

B refer to category relationship

b_1 is O

b_2 is E

b_3 is S

Source	SS	df	VE	F	p
Blocks	990.84	9	110.09	15.98	<0.01
Treatments	471.84	8	58.98		
A	196.27	2	98.14	14.24	<0.01
B	173.48	2	86.74	12.59	<0.01
A B	102.09	4	25.52	3.70	<0.01
Residual	496.02	72	6.82		
Total	1958.70	89			

Table a Summary table for type RBF 3 x 3 design for diagramming times on all items in list format

Source	SS	df	VE	F	p
Blocks	990.84	9	110.09	15.98	<0.01
A	196.27	2	98.14	14.24	<0.01
A at b_1	37.60	2	18.80	2.72	n.s.
A at b_2	54.65	2	27.33	3.96	<0.05
A at b_3	206.11	2	103.01	14.95	<0.01
B	173.48	2	86.74	12.59	<0.01
B at a_1	14.03	2	7.02	1.02	n.s.
B at a_2	206.48	2	103.24	14.98	<0.01
B at a_3	55.06	2	27.53	4.00	<0.05
A x B	102.09	4	25.52	3.70	<0.01
Residual	496.02	72	6.89		
Total	1958.70	89			

Table b   Summary table for simple main effects for diagramming times on all items in list format

SIGNIFICANT CONTRAST	p
A/A/2/E > E/E/1/E	<0.05
I/I/4/E > E/E/1/E	<0.05
I/I/4/S > A/A/2/S	<0.01
I/I/4/S > E/E/1/S	<0.01
I/I/4/S > I/I/4/O	<0.01
I/I/4/S > I/I/4/E	<0.01

Table c Significant contrasts for item types in list format

APPENDIX 5

RESULTS SUMMARY TABLES FOR EXPERIMENT 6

EXPERIMENT 6 (ANOVA Summary Tables a, c, d, e, f, g, h, i, k, l, m, n)

Source	SS	df	VE	F	p
Between	18.01	2	9.01	0.23	n.s.
Within	2319.44	60	38.66		
Total	2337.45	62			

Table a Summary table for type CR-3 design for mean diagramming times on correct items in the three experimental conditions

		$\overline{X}$	SD
CONDITION 1	O	17.69	10.78
	E	12.45	5.74
	S	13.10	8.21
	H	12.40	5.31
CONDITION 2	O	14.26	8.04
	E	11.85	6.34
	S	13.02	7.07
	H	11.77	6.80
CONDITION 3	O	16.86	7.50
	E	12.90	7.32
	S	14.45	8.75
	H	14.25	8.50

Table b Means and standard deviations of correct diagramming times for the four known category relationships (O,E,S and H) for each of the experimental conditions

Source	SS	df	VE	F	p
Between treatments	368.50	3	122.83	5.41	<0.01
Between blocks	3395.91	18	188.66	8.31	
Residual	1225.43	54			
Total	4989.84	75			

Table c Summary table for type RB-4 design for mean diagramming times on correct O,E,S and H items in condition 1

Source	SS	df	VE	F	p
Between treatments	138.49	3	46.16	2.47	n.s.
Between blocks	3226.72	16	201.67	10.56	
Residual	916.82	48	19.10		
Total	4282.03	67			

Table d Summary table for type RB-4 design for mean diagramming times on correct O,E,S and H items in condition 2

Source	SS	df	VE	F	p
Between treatments	138.49	3	46.16	2.47	n.s.
Between blocks	3226.72	16	201.67	10.56	
Residual	916.82	48	19.10		
Total	4282.03	67			

Table e Summary table for type RB-4 design for mean diagramming times on correct O,E,S and H items in condition 3

Source	SS	df	VE	F	p
Between	116.79	2	58.40	3.53	<0.05
Within	991.52	60	16.52		
Total	1108.31	62			

Table f   Summary table for type CR-3 design for subjects diagramming errors in the three experimental conditions

Source	SS	df	VE	F	p
Between	53.18	2	26.59	4.71	<0.05
Within	338.48	60	5.64		
Total	391.66	62			

Table g   Summary table for type CR-3 design for subjects type a diagramming errors in the three experimental conditions

Source	SS	df	VE	F	p
Between	43.55	2	21.78	4.11	<0.05
Within	317.71	60	5.30		
Total	361.26	62			

Table h   Summary table for type CR-3 design for subjects diagramming errors on balanced items in the three experimental conditions

Source	SS	df	VE	F	p
Between	14.70	2	7.32	1.25	n.s.
Within	352.38	60	5.87		
Total	367.08	62			

Table i   Summary table for type CR-3 design for subjects diagramming errors on unbalanced items in the three experimental conditions

		$\overline{X}$	SD
CONDITION 1	O	0.29	0.24
	E	0.06	0.09
	S	0.36	0.33
	H	0.39	0.27
CONDITION 2	O	0.33	0.33
	E	0.06	0.09
	S	0.17	0.18
	H	0.21	0.25
CONDITION 3	O	0.45	0.29
	E	0.10	0.16
	S	0.41	0.32
	H	0.40	0.29

Table j   Means and standard deviations for errors made on O,E,S and H items in each of the experimental conditions

(For O and E items frequency errors $/_7$, for S and H items frequency errors $/_5$.)

Source	SS	df	VE	F	p
Between treatments	1.41	3	0.47	8.18	<0.01
Between blocks	2.19	20	0.11	1.90	
Residual	3.45	60	0.06		
Total	7.05	83			

Table k Summary table for type RB-4 design for mean errors on O,E,S and H items in condition 1

Source	SS	df	VE	F	p
Between treatments	0.79	3	0.26	9.79	<0.01
Between blocks	2.72	20	0.14	5.03	
Residual	1.62	60	0.03		
Total	5.14	83			

Table 1 Summary table for type RB-4 design for mean errors on O,E,S and H items in condition 2

Source	SS	df	VE	F	p
Between treatments	1.33	3	0.44	8.00	<0.01
Between blocks	2.72	20	0.14	2.46	
Residual	3.32	60	0.06		
Total	7.38	83			

Table m Summary table for type RB-4 design for mean errors on O,E,S and H items in condition 3

Source	SS	df	VE	F	p
Between	90.02	2	45.01	23.11	<0.01
Within	116.88	60	1.95		
Total	1206.90	62			

Table n Summary table for type CR-3 design for subjects mean unknown category naming times in the three experimental conditions

Source	SS	df	VE	F	p
Between	20.22	2	10.11	1.14	n.s.
Within	533.43	60	8.89		
Total	553.65	62			

Table o Summary table for type CR-3 design for subjects unknown naming errors in the three experimental conditions

APPENDIX 6

INSTRUCTIONS FOR EXPERIMENTS 1, 2, 3, 4, 5 and 6

APPENDIX 6(a) INSTRUCTIONS FOR EXPERIMENT 1

Instructions to subjects

In this experiment, your task is to learn the values of four characteristics for each of four different paints. The four paints are RED, YELLOW, BLUE and WHITE. The four characteristics are PRICE, DURABILITY, GLOSS and TEXTURE. Each of the characteristics has a possible value from 1 to 9 inclusive. Your task is to learn these values for each paint by asking questions of the experimenter.

Examples of questions you might ask are:

"What is the price of yellow paint?"
"What is blue paint's gloss?"
"What is the texture of white paint?" etc.

In reply, the experimenter will inform you of the value of the characteristic for that particular paint.

Because there are four paints and four characteristics, there are sixteen questions in all. You may ask as many questions as you like, in any order but you may only ask questions for 8 minutes. The experimenter will inform you when your time is up. You will be tested on your learning when you have completed the task. Any questions?

APPENDIX 6(b) INSTRUCTIONS FOR EXPERIMENT 2

Instructions to subjects

You are about to participate in a learning experiment in which you are required to learn about four characteristics of four different colour paints. The four paint colours are RED, YELLOW, BLUE and WHITE. Each of the four paints has four characteristics associated with it. These four characteristics are PRICE, DURABILITY, GLOSS and TEXTURE. Each characteristic for each paint colour can take a value of 1 to 9 inclusive. There are therefore sixteen possible statements for each paint and attribute. Examples of such statements are:

PRICE OF RED IS 4
GLOSS OF BLUE IS 7
TEXTURE OF WHITE IS 8
DURABILITY OF YELLOW IS 3 etc.

Each of the sixteen statements is printed on one side of a card. Your task is to learn all the statements by progressing through the cards one by one by picking the top card off the pack. After you have finished with each card place it print side downwards to one side of the original pack, forming a separate pile. You have five minutes to learn the statements and you may work at your own pace. You can work through the pack any number of times, but you may not go back to a card once you have placed it in your separate pile. When working through the cards on a second or subsequent occasion, simply turn over your pile of cards and start again. The experimenter will tell you when your time is up.

When you have finished this task, you will be asked to recall the values of the paint characteristics in a particular order. You will be given another pack of cards identical to the previous pack, but without the values. Examples of statements on this pack are:

PRICE OF RED
DURABILITY OF BLUE
GLOSS OF WHITE
TEXTURE OF YELLOW, etc.

Your task is to recall the values for each statement by writing them on the piece of paper provided. To do this read the top card of the pack, write the value on the piece of paper, and place the card face side downwards to one side of the pack. Do the same with the next card and so on. You will have as long as you like to do this but you have only one opportunity to recall each statement. You may not go back to correct any answers.

Any questions?

APPENDIX 6(c) INSTRUCTIONS FOR EXPERIMENT 3

Instructions to subjects

You are about to participate in a learning experiment in which you have 5 minutes to study a passage containing descriptions of a number of imaginary people.

Your task is to remember as many of the statements from the passage as possible.

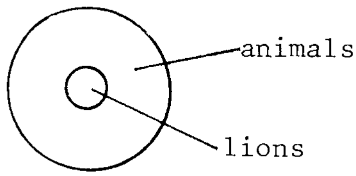
After the experimenter has informed you that the time is up, you will be given a number of questions on cards, which you will answer on the piece of paper provided. You can answer questions at your own pace but you cannot correct a question or go back once you have answered it.

Any questions?

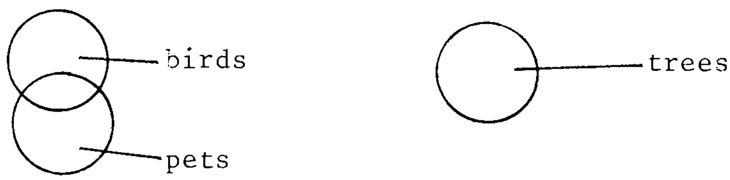
APPENDIX 6(d) INSTRUCTIONS FOR EXPERIMENT 4

Instructions to subjects

Sometimes the relationships among groups of things are best explained by diagrams that consist of overlapping circles. For example, if certain specific things, let's say lions, all belong to one larger class of things, let's say animals, you could diagram the situation as follows:



In these diagrams we do not care about the relative sizes of any of the circles. That is, we are not suggesting here that a relatively large proportion of animals are lions, but we are indicating that all lions are animals. That is why the circle representing lions is drawn entirely within the circle that represents animals. Now take the relationships among three groups of different things; birds, pets and trees. These should be diagrammed as follows:



This diagram shows that no trees are either pets or birds, but some birds are pets and some pets are birds.

Each item in this test names three groups of things. You are to draw the diagram which shows the correct relationship among the three groups in each item.

Each item will be presented to you on a card. Here are some examples of items. The groups you are to diagram are printed in capital letters.

ITEM 1. All CABBAGES are PLANTS
All VEGETABLES are PLANTS

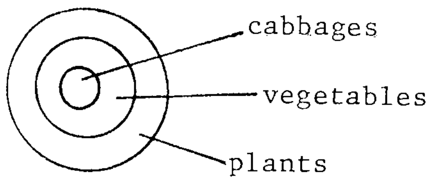
ITEM 2. No PEQ are DRINKS
No LIQUIDS are PEQ

ITEM 3. Some MEN are REH
Some REH are PARENTS

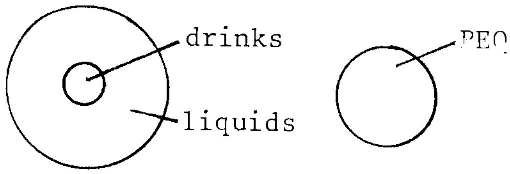
ITEM 4. All BEDS are FURNITURE
All CHAIRS are FURNITURE

For these four items you should have drawn the following diagrams:

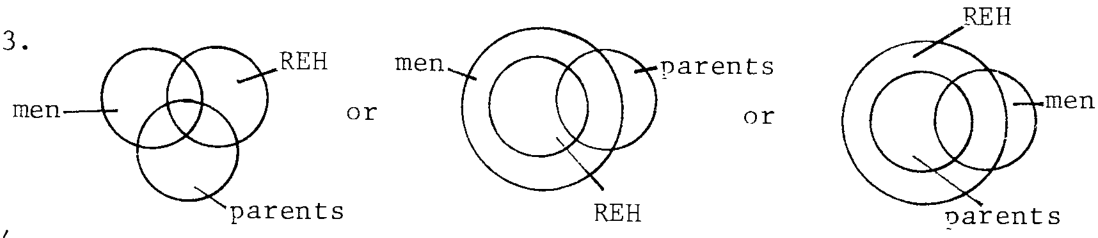
ITEM 1.



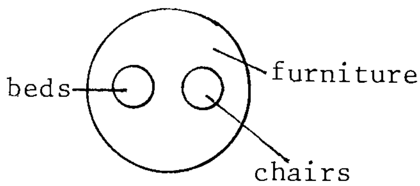
ITEM 2.



ITEM 3.



ITEM 4.



From these examples you can see that some items contain three groups that you know whereas others contain two groups you know and one group you don't know. For both types of item use your knowledge of the groups you know and the information in the item to draw the correct relationship. There are no "trick" items.

After being presented with the test item your task is to draw the correct diagram on the paper provided. You will be timed on this and you are to work as quickly as possible without making any errors. If you have incorrectly drawn a diagram cross it out and redraw the correct one. When you are satisfied with your diagram say "RIGHT" so the experimenter can stop the clock.

While the experimenter is noting your time for each item mark each of your three circles in your diagram with a 1, 2 or 3 to show the order in which you drew them. Mark 1 on the first circle you draw, 2 on the second circle, and 3 on the third. After you have marked the order in which you drew your circle, label each circle with the group name associated with it.

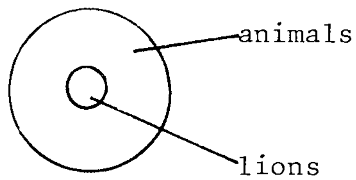
You will now be given five practice items to familiarise you with the procedure.

<u>Any questions?</u>

APPENDIX 6(e) INSTRUCTIONS FOR EXPERIMENT 5

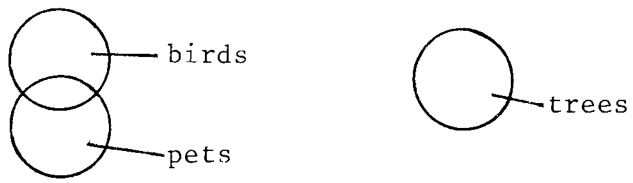
Instructions to subjects

Sometimes the relationships among groups of things are best explained by diagrams that consist of overlapping circles. For example, if certain specific things, let's say lions, all belong to one larger class of things, let's say animals, you could diagram the situation as follows:



In these diagrams we do not care about the relative sizes of any of the circles. That is, we are not suggesting here that a relatively large proportion of animals are lions, but we are indicating that all lions are animals. That is why the cicle representing lions is drawn entirely within the circle that represents animals.

Now take the relationships among three groups of different things: birds, pets and trees. These should be diagrammed as follows:



This diagram shows that no trees are either pets or birds, but some birds are pets and some pets are birds. Each item in this test names three groups of things. You are to draw the diagram which shows the correct relationship among the three groups in each item.

Each item will be presented to you on a card. Here are some examples of items:

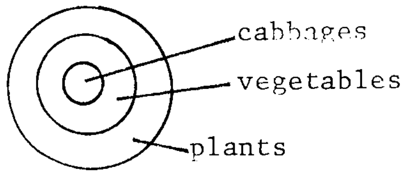
ITEM 1 CABBAGES, PLANTS, VEGETABLES

ITEM 2 BEDS, FURNITURE, CHAIRS

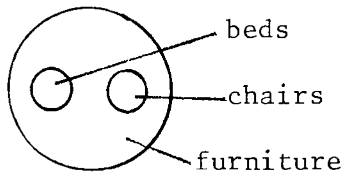
ITEM 3 ANIMALS, CATS, PENCILS

For these three items you should have drawn the following diagrams:

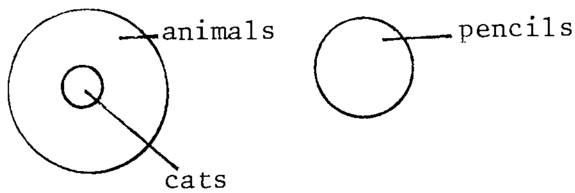
ITEM 1



ITEM 2



ITEM 3



After being presented with the test item your task is to draw the correct diagram on the paper provided. You will be timed on this and you are to work as quickly as possible without making any errors. If you have incorrectly drawn a diagram, cross it out and redraw the correct one. When you are satisfied with your diagram say "RIGHT" so the experimenter can stop the clock.

While the experimenter is noting your time for each item mark each of the three circles in your diagram with a 1, 2 or 3 to show the order in which you drew them. Mark 1 on the first circle you draw, 2 on the second circle, and 3 on the third. After you have marked the order in which you drew your circles label each circle with the group name associated with it.

You will now be given five practice items to familiarise you with the procedure.

Any questions?

APPENDIX 6(f) INSTRUCTIONS FOR EXPERIMENT 6

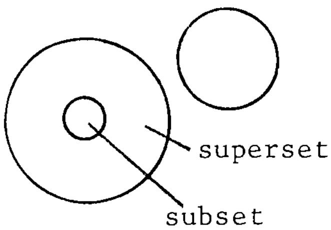
Subjects in Experiment 6 received the same set of instructions as those in Experiment 4 but in addition all subjects in Experiment 6 received additional instruction on subsets and supersets and how they should be dealt with in category inclusion items. These are shown below.

Instructions to subjects

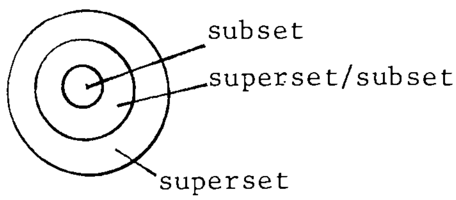
You should now understand how to diagram and label relationships. A number of the items in the test contain relationships which have one category totally included in another. These are called subset/superset relationships. A few examples of diagrams where category inclusions are present and not present are given below.

CATEGORY INCLUSION ITEMS

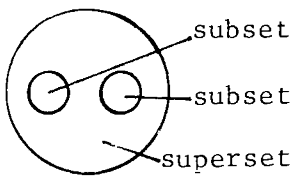
a)



b)

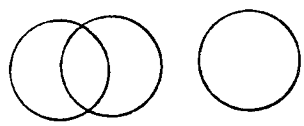


c)

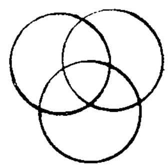


NO CATEGORY INCLUSION ITEMS

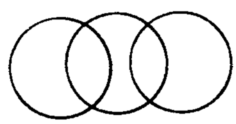
d)



e)



f)



(Each of the three experimental conditions in Experiment 6 had a set of additional instructions as shown.)

Instructions to subjects for Condition 1

For items which contain subset/superset relationships you must diagram any superset(s) before any subsets(s).

Of course this rule does not apply to items which do not contain such category inclusions.

Any questions?

Instructions to subjects for Condition 2

For items which contain subset/superset relationships, you must diagram any subset(s) before any superset(s).

Of course this rule does not apply to items which do not contain such category inclusions.

Any questions?

Instructions to subjects for Condition 3

For items which contain subset/superset relationships you can diagram subset(s) and superset(s) in any order.

Of course, not all items contain such category inclusions.

Any questions?

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